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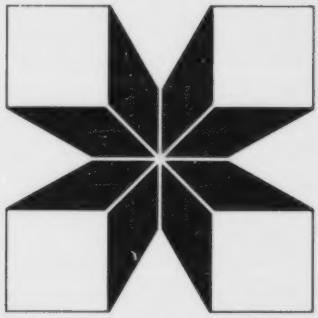
COMPUTERS IN KENYA'S SECONDARY SCHOOLS

CASE STUDY OF AN INNOVATION IN EDUCATION



B.M. MAKAU

COMPUTERS IN KENYA'S SECONDARY SCHOOLS

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COMPUTERS IN KENYA'S SECONDARY SCHOOLS

Case study of an innovation in education

B.M. Makau

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ACKNOWLEDGEMENT

I wish to express my gratitude for the assistance which, in conducting the study reported here, the research team received from institutions and individuals. A number of overseas institutions provided us with opportunities to discuss the project and the study with scholars and professionals involved in similar work. Among these institutions were the World Bank, UNESCO, USAID, British Council, Florida State University at Tallahassee, University of London Institute of Education and the Open University of the UK. The Institute for Development Studies of the University of Nairobi gave us an opportunity to discuss interim findings of the study at a seminar in May 1988. On a number of occasions, Kenya-based scholars in education graciously gave us their views on the project and the study.

In conceptualising the study, we benefited a great deal from discussions with Dr Ward Heneveld, Dr Jeremy Greenland, Dr David Court, Dr Sheldon Shaeffer, Dr George Papagiannis, Dr Steven Klees and Mr Brian Wray. Dr Steven Klees of Florida State University, Tallahassee made very useful suggestions as to how the cost aspect of the study could be approached. He also read drafts of Parts 1 - 5 of the final report and assisted with the analysis of the cost data, as well as making suggestions on the organisation of the report. Particularly important were Steven's suggestions on the relationship between the project's per student costs and replication of the innovation. Dr George Papagiannis of Florida State University, Tallahassee helped in setting up the research station and in introducing the research team to the microcomputer as a research tool. In discussions held in Nairobi and Tallahassee, we benefited a great deal from George's extensive knowledge of the role and evaluation of technology as an educational resource. Dr Jeremy Greenland, Dr David Court, Dr Sheldon Shaeffer and Mr Wray made helpful comments on our interim research reports. As project director, Mr Wray made himself available for discussion with the research team; over a few issues there were differing professional points of view, but in total we learned a great deal from him.

We are most grateful to the heads, staff and students of the project schools. They allowed us to intrude into their busy schedules, answered our verbal and written questions, and allowed us to examine some of their documents, as well as observing various activities in their schools. Without the co-operation we received from the schools, it would not have been possible to carry out the study.

The Aga Khan Foundation (AKF) and Apple Inc. of the USA funded the project on which this study was was carried out. Funds for the study were generously provided by AKF, the International Development Research Centre (IDRC) and the Rockefeller Foundation. We are most grateful to the four donors for making it possible for us to gain experience in computer technology and to study its role in education. We would like

to pay a special tribute to IDRC for undertaking the costs of publishing this report. The Nairobi offices of AKF and the Aga Khan Education Service (AKES) very ably administered the research funds, and promptly attended to the study's administrative needs. We are particularly grateful for the role played by Mr Azim Rajan and his successor as Chief Executive Officer AKF (Kenya), Mr Alnashir Visram, and Mrs Shamim Maurivard, Executive Officer at AKES (Kenya).

Dr Catherine Namuddu and Mr Joseph O'Connor were the other two members of the research team. I would like to express my gratitude for their companionship and invaluable contribution to all aspects of the study. The role they played in developing the research proposal, preparation of research tools, data collection and analysis, and interim report writing made this final report possible. The research team benefited a great deal from Catherine's knowledge and experience of ethnographic approaches to research in education. Joe's flair for statistical analysis was equally helpful. Both Catherine and Joe read drafts of this report and, as usual, made very useful suggestions.

While acknowledging the contribution made by my two colleagues in the research team and the assistance received from other professionals and scholars, I take full responsibility for any errors, omissions, biases, interpretation of data, conclusions, and policy and planning recommendations in this report.

EXECUTIVE SUMMARY

Since the emergence of the microcomputer in the late 1970s, developed countries have embarked on ambitious projects to introduce the new technology into schools. The integration of the technology into school learning has been argued to be an ideal way of improving or even reforming traditional curriculum processes and thus, maximising a nation's competitiveness in the international market-place. Scholars, educationists and electronic experts have made claims that the computer is capable of transforming the teaching-learning transaction from being a dull teacher-dominated activity geared to dishing out factual knowledge, to an exciting learner-centred process which nurtures confidence, initiative and mental skills, such as problem- solving and reasoning. It is argued that these attitudes and mental skills, which develop the personality of the individual, are the prerequisites of success in future life.

While influential sectors of third world societies have been aware of the potential of computer technology in the work- place and have put pressure for the introduction of the technology into institutions of learning, the computerisation of schools in countries like Kenya remains problematic. First, most third world countries are faced by severe constraints in financing both quantitative and qualitative improvements in education. Given that, as opposed to investing available resources into improving traditional learning resources (such as textbooks and teacher quality) the purchase of computer technology appears to be much more expensive, there is a justifiable caution in embarking on computerising schools. Second, to many third world educational planners, claims made in the developed world that the computer could revolutionalise curriculum processes appear to be vague and unsubstantiated. While most evaluations of the role computers are playing in schools of developed countries point to some advantages in using the technology, the evaluations highlight a string of problems and are short of clear evidence that computerisation results in significant gains in students' academic achievement. Some of the evaluations and research reports end up recommending drastic restructuring of traditional curricula and a move towards making the computer to learner ratio one to one. Both recommendations are, for the foreseeable future, too expensive for most third world countries.

Some of the modest attempts to computerise third world schools have been subjected to some evaluation but, by and large, lack of systematic knowledge as to the potential and problems of computerisation is more characteristic. This report discusses a study which, while bearing in mind the claims made for school computers in developing countries and the reservations which third world planners might have, set out to document the interrelationships between the objectives, implementation and outcomes of a donor-funded computers in education project in Kenya. Three important aspects of the project should noted. First, the project set out to experiment on the viability of providing a small number of

computers and limited software to a school. Second, the main thrust was to integrate the technology into the existing curriculum and to improve school management, rather than to introduce computer science as a new subject. Third, although some student exposure to the technology was contemplated, the emphasis was on using the computer as a catalyst to initiate changes in teacher pedagogical perceptions and practices.

The report is organised into seven parts as follows:

Part 1 (a) discusses the context in which computers are being introduced into schools (b) briefly describes the Kenya education system (c) describes the structure of the project, including its objectives, the equipment provided and the project office (d) discusses the objectives, methodology and approaches of the research and evaluation component.

Part 2 discusses inputs into the innovation, i.e. the entry characteristics of staff and students, the philosophy of the implementation, approaches to the implementation (including the on-the-job education of the implementation team, the role played by teacher tutors and consultants in workshops, the development of school media co-ordinators, the organisation of workshops and seminars for school staff, interaction between the project office and the schools, and the physical deployment of project equipment in the schools). Of particular importance is the implementation strategy whose main thrust was that (through workshops and visits to schools by the implementation team) school staff were to be introduced to various uses of the technology, and then, with help from peers, be expected to explore the technology and develop fresh pedagogical perceptions and practices.

Part 3 discusses staff and student uses of the technology. As a measure of success of the innovation, data is presented to show that in all schools in the study the technology was being used by a core of teachers and a sizeable proportion of the students. In terms of functionality, data is discussed to show that considerable advances were made in using the technology in school management, monitoring students' academic progress, production of teaching and learning materials, and improvement of students' out-of-class activities (including the production of school magazines, playing of computer games, learning how to use general application programs, and introduction to programming). In the crucial sphere of integrating the technology into the existing curriculum, evidence is presented to show that the innovation resulted in the development of new pedagogical perceptions, and that some teachers used the technology to conduct imaginative and interesting lessons in which students were observed to be highly motivated and actively involved. However, it is also shown that although in some of the schools computer-assisted lessons were fairly common, most teachers tended to treat such lessons as add-on activities in which the teacher did not play an active professional role. This evidence is in contrast with data which shows that the students perceived learning activities involving the computer as most useful when the teacher was actively involved. Further, it is pointed out that there was no evidence that new pedagogical perceptions associated with the innovation were translating into lessons in which

the computer was not in use.

Part 4 discusses barriers to the use of the technology by school staff and students. Among the barriers discussed are (a) snags in the school management system (b) problems in the procurement, maintenance and deployment of hardware and software (c) technical, attitudinal and time constraints in mastering the technology (d) time and philosophical constraints in the conduct of teacher development activities (e) gender issues in the use of the technology by students.

Part 5 discusses the monetary costs of the project. Evidence is presented to show that three of the schools were in a position to mobilise local resources to fund the procurement and maintenance of the technology. By way of extrapolation, it is argued that a few other Kenyan schools of similar standing could participate in a wider replication of the innovation. However, data is presented to show that, because of the high costs involved in computerising schools and the shortcomings of imported educational software, wider replication should be planned with caution.

Part 6 is an overview of the discussion in Parts 1 to 5. The overview has two major thrusts. First, basic reasons are given as to why the innovation was a distinct success in some spheres. It is argued that in the sphere of school management and teacher production of teaching and learning materials, the technology was readily embraced because school staff felt that use of the computer would enable them to be more efficient in performing tasks which were already part of their responsibilities. With regard to students' response to the innovation, data is presented to show that the excitement associated with the computer was a manifestation of student preference for learning as a natural process, i.e. learning which built on existing knowledge and allowed for full active involvement of the learner. A second major thrust in Part 6 is a discussion of the social setting, the level of funding, hierarchy and authority in the school system, and the dissemination strategy as factors which inhibited the integration of the technology into the normal curriculum. In relation to both students and teachers, it is argued that because of attitudinal and time constraints associated with the examination-driven curriculum, acceptance of the teaching and learning approaches advocated by the innovation was at best lukewarm.

In Part 7, the findings of the study are summarised and used as the basis for making policy and planning recommendations. The salient features of the recommendations are as follows. First, because of the increasingly important role of computer technology in the economies of Kenya and other third world countries, policy and planning should as a matter of urgency take steps to introduce computers to schools which are able to raise the necessary funds. Second, planning should take into account the lessons learned from the Kenya-based project: the beneficial outcomes should be seen as a sufficient justification for contemplating use the computer as an educational resource in schools, while the factors which inhibited the innovation should be treated as pointers to pitfalls to be avoided. Third, the computerisation of schools should be planned

as part of the overall national effort to improve curriculum processes. Fourth, careful thought should be given to a graded introduction of the technology to the school community. Areas in which the computer's comparative advantage are easily identifiable should be introduced first. Fifth, use of the computer as a catalyst in developing new teacher perceptions and practices requires focused and sequenced didactic approaches by the trainers. Sixth, each school should ensure that official channels for professional interaction (e.g. subject departments) play a central role in integrating the technology into the curriculum. Part 7 concludes with a list of suggested objectives for a wider replication of a computer innovation similar to the Kenyan one.

PART 1

SETTING OF THE STUDY

INTRODUCTION

The Computers in Education Project in Kenya (CEPAK) was launched in April 1983. At the pilot phase, with funding from the Aga Khan Foundation (AKF), a small number of computers was introduced into a private secondary school in Nairobi. In the course of the succeeding two years CEPAK was subjected to both in-house and external evaluation (Wray 1983, Heneveld 1984, Wray 1984, Kirmani 1985, Papagiannis 1985, Gakuru & Kariuki 1986) which judged the project to have successfully developed such that it merited expansion. As a consequence, additional funding was obtained from Apple Inc., the International Development Research Centre and the Rockefeller Foundation, and in mid-1986 a three-year phase II was launched. Five more secondary schools were brought into the project. Further, the funding agencies decided that, over the three year period of Phase II, the innovation should be studied and evaluated by an independent research team. Three educational researchers were contracted to carry out the study.

CEPAK was initiated because a section of the Kenya community was keen on developing a role for computers in some schools. This local interest was to an extent a response to technological advances and educational thinking taking place in the developed North (Makau & Wray 1987). In relation to the supply of equipment, and the evolution of technological and educational ideas, the project continued to be influenced by the developed world. However, while important, external influences did not mean that the project simply replicated attempts to computerise schools in the developed world. CEPAK acquired a local character, particularly by way of objectives and approaches which attempted to take the Kenyan educational context into account. In order for the project to be understood in the wider context, the following section briefly discusses the circumstances which have influenced the entry of the computer into schools.

THE ADVENT OF COMPUTERS INTO SCHOOLS

Developed Countries

Since the late 1970s, one of the most significant features of education systems in the developed North has been the large-scale introduction of computers into schools. In 1987 a report on educational computing within members of the Organisation for Economic Cooperation and Development (OECD) stated:

> Seven member countries now claim that between 98 and 100 per cent of their secondary schools are "equipped", even if supply

> varies significantly both within and between these countries. Scottish secondary schools have 20 microcomputers on average, and the average for Australia, Denmark, France, England and Wales, Iceland and the United States, lie between 9 and 18 per school.[1]

In 1987, the American state of California - with an elementary and secondary school enrolment of about 4.2 million - had about 135,000 computers in schools, that is a ratio of one computer to 31 students (Electronic Learning, 1987).[2] In 1988 the Canadian province of Ontario (1,816,315 students in 4,508 schools with 77,271 computers) had a computer to student ratio of 1:23 (Hubert 1988).[3]

To a large extent, in the developed North, the introduction of computers into schools originated from without the education system. Computerisation of schools stemmed from technological advances in micro-electronics which led to the manufacture of increasingly cheaper but smaller and more powerful computers (Friend, 1987). These developments resulted in the emergence of the personal computer (microcomputer) in the mid-1970s. Sewell and Rotheray (1987) point out that, capitalising on the lower prices (relative to those of mainframe and mini computers), "government funded programmes, local initiatives involving teachers, user groups etc., and pressures from computer manufacturers who have frequently offered attractive discounts to educational purchasers"[4], have ensured that computers are provided to schools in increasing numbers. The advent of the personal computer into the home and the widespread use of the technology in the management of public affairs, and in business and industry have also exerted pressure on school systems to incorporate the technology into curricula (Becker 1984, Anderson 1985, Wangberg 1985, Naiman 1987). With reference to large-scale computerisation of schools in France in the mid-1980s, Dieuzeide (1987) summarises the foregoing external pressures - also important in developing countries - as follows:

> Although not always in full agreement, industry, the public authorities, economic and financial circles, families and the media have been involved at all stages in the introduction of

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1. Scottish Education Department in cooperation with OECD. Implications for Teacher Education - Report of an International Seminar, p. 2, October 1987.

2. Electronic Learning Vol. 7, No. 2. Educational Technology 1987 - A Report on EL's Seventh Annual Survey of the States, p. 53, October 1987.

3. Hubert, N. The 1988 Computers in Education Survey - Classroom Computers Across Canada. Computers in Education: Canada's Computing Magazine for Education 5.7, p. 15, April 1988.

4. Sewell, D.F. & Rotheray, D.R. The applications of Computers in Education. Prospects 17.3, p. 379, 1987.

> computer science into education and its subsequent spread. As in the other industrialized countries, the arguments used to justify this process hinged on international competition and the preservation of national independence, the modernization of industry and the growing importance of communication in all fields.[5]

The new information technology (IT) - defined to include computers, interactive video and telecommunication devices (Hawkridge, 1983) - has influenced formal education in two major ways. First, IT has been used as a vehicle for improving existing school curricula and school management processes. Second, educational researchers and reformers who find fault with traditional curricula and the existing practices in education have latched on to IT as a tool which has the potential for effecting fundamental changes in the perceptions of and approaches to learning. Each of the two applications of IT in education are discussed below.

According to Bird (1984) and Bitter & Camuse (1984), use of computers to improve existing curricula and school management processes has taken the form of one or a combination of three approaches. First, through new subjects (such as computer literacy and computer science), the technology has been introduced as the object of study, with teaching-learning being geared to the acquisition of an understanding of the applications of computers in the work- place and their implications in the wider society. This approach, whose most manifest form is the teaching and learning of computer programming, has firmly taken root in schools in the developed north (Becker 1984, Correa 1989).[6] A second approach has been to use the computer as an educational resource in the existing curriculum. This approach has relied on subject-specific software (drill-and- practice, tutorials and simulations), computer games, and/or general application software (such as wordprocessors, data managers, spreadsheets and graphics programs). The third approach has been in the development of computer-managed education, that is, use of the technology in administrative spheres such as timetabling, management of students' records, production of teaching and learning materials, monitoring academic progress, analysing test data, financial management and storekeeping.

With regard to using IT to make fundamental changes in education, scholarly works such as McLuhan (1964), Papert (1980a, 1980b), Bork (1980), Dwyer (1980), Postman (1980), Becker (1984), Norton (1985), Evans (1986), Dede (1987), Hunter (1987) view IT as having the potential to enhance learning as an individualised and active process which cumulatively builds on the experiences of the learner and develops in him or her problem-solving skills. Echoing current thinking in cognitive psychology, which underscores the need for educational strategies to take

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5. Dieuzeide, H. Computers and Education: the French Experience. Prospects 17.4, p. 531, 1987.

6. Becker, H.J. Computers in Schools Today: Some Basic Considerations. The American Journal of Education 18.2, 1984.

account of the development of the whole person, Norton maintains that understanding "in a media environment bypasses to a large extent the language and print dominated centres of the left brain and taps the more intuitive, pattern-seeking centres of the right brain... As the new information technologies tap both subjective feelings and objective abstractions, the purely logical world of science and the affective world of art and religion give way to interconnectedness."[7] In agreement with Dwyer that "education is that which liberates human potential, and thus the person"[8], Papert sees the computer as providing a base for reform of traditional curricular approaches: "I am proposing ...to use the computer... not to coax the student along the difficult and unnatural path adopted by traditional curricula, but to open up a natural path along which the student can drive himself or herself."[9] Becker sees the computer as having the "ability to create intellectually stimulating environments for students to explore subject matter generally foreign to the current curriculum, perhaps beyond the competency of the teacher, but important and useful preparation for the student's future life."[10] With emphasis being put on the "learner being in control of his or her learning", it has been advocated that the teacher should change from being the source of knowledge to become an organiser and facilitator of learning (Collis 1989).

Developing Countries

Although to a much lesser extent than in the developed north, developing countries have joined the 'computers in schools' bandwagon (Chan Kong Chan 1986, Oteiza 1987, Scott 1987, Nissen 1988, Camara 1989, Chaundry

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7. Correa, C.M. Informatics in Education: Objectives, Requirements and Costs. Paper presented at a UNESCO Conference on Education and Informatics, April 1989. He refers to a report in the New York Times to the effect that in 1984, 64% of computing time in secondary schools was devoted to computer literacy - mainly programming in BASIC.

Norton, P. An Agenda for Technology and Education: Eight Imperatives. Educational Technology - The Magazine for Managers of Change in Education 25.1, p. 17, 1985.

8. Dwyer, W. Heuristic Strategies for Using Computers to Enrich Education. In Taylor, R.P. (ed.), The Computer in the School: Tutor, Tool, Tutee, p. 88. New York: Teachers College Press, 1980.

9.

10.

et al. 1989, Makrakis 1989, Wai-Kong Ng 1989). The entry of computers into the education systems of developing countries mirror developments in the North in two important ways. First, pressure for computerisation is being exerted from without the education system. Second, computerisation of schools is being advocated at a time when fundamental thinking about curricula and the role of formal education in the wider society is taking place.

Like in the industrialised North, developing countries regard the computerisation of schools as an essential element in the wider effort to gear modern technology to national development, thereby increasing a country's competitiveness in the international market place (Akinlade 1986, Allotey 1986, Verghese 1986, Hobday 1986, Ramiszowski 1986, Oteiza 1987). Great hopes for rapid economic development are being pinned on the adoption of modern technology, including new IT, with educational institutions being prompted to play a role in its adoption and adaptation. Although to date Kenya has not developed a detailed policy on computerisation of schools, her current national development plan (Republic of Kenya 1989) views IT as a tool in development as follows:

> At the threshold of the twenty-first century, the dawn of the information revolution promises to carry the human race to (great) heights of technological achievement. The primacy of information as a tool for development planning is increasingly becoming appreciated by planners, decision-makers, investors and the public at large...Government policy will, therefore, continue to encourage the adoption of appropriate information technology and to facilitate its development and acquisition not only in the context of industrial production of hardware and software...but also through training and development of the necessary technological manpower."[11]

On another plane, many developing countries are in the process of reforming curricula and education systems inherited from former imperial masters. The reforms, in several ways not unlike the IT-related changes being advocated in the north, aim at making educational processes relevant to the overall development of society. Among aspects which are receiving prominence is the need for education which emphasizes practical approaches using both indigenous and imported technology (Fransman & King 1984), and experiences which - through active participation in learning activities - help learners to acquire attitudes and skills necessary for self-reliance in life after school. Reporting on a 1984 conference in which educational priorities in Africa were discussed, Hawes et al. (1986) maintain that there was consensus that

> Africa needed people who could make do, produce and create, fix and repair, improvise and innovate, grow, process, design, erect, maintain and make good. Africa's education systems were

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11. Republic of Kenya. Development Plan, 1989-1983. Nairobi: Government Printer, pp. 95-96, 1989.

not delivering the goods, hence the priority which should be accorded to technical and vocational education.[12]

In a keynote paper to the conference, Porter (1986) advocated a school curriculum which incorporates a "subtle process of changing the character of the subjects taught to give them a self-help orientation with a view to increasing the capacity and the desire of the recipients to initiate change in their subsequent lives."[13]

By the mid-1980s the reform of school curriculum in Kenya (which has received attention from scholars, policy makers and planners) had been translated into a new system of education. By the early 1970s scholars were already urging changes in school curricula. For instance, Ghai (1974) argued that in Kenyan schools, "the method of instruction needs to move away from mechanical absorption of information towards greater emphasis on learning by doing and problem solving" and that "the content and process of education need to be related to the local social and economic environment."[14] In the mid-1970s a committee set up by the government to chart new directions in education (Republic of Kenya 1976) recommended that schools should "develop the intellectual, spiritual and physical potential of the country's human resources for the purposes of raising the overall productivity and quality of life in the country", and that an important approach in this direction should be for curricula to "include the teaching of pre-vocational craft-orientated skills, including small-scale business techniques, in order to encourage self-confidence, creative ability and evaluative capacity".[15] These recommendations received support from another government committee in the early 1980s (Republic of Kenya 1981) and became the base on which new school curricula were developed and progressively introduced with effect from 1984 (Republic of Kenya 1984).

The stated objectives of the current primary and secondary school curriculum in Kenya can be grouped into three categories. First, there

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12. Hawes, H., and Coombe, T., with Lillis, K. Education Priorities and Aid Responses in Sub-Saharan Africa - Report of a Conference at Comberland Lodge, Windsor, 4-7 December 1984. London: Overseas Development Administration and University of London Institute of Education, p. 45, 1986.

13. Porter, A.T. Education Priorities in Sub-Saharan Africa. In Hawes et al. (see note 12).

14. Ghai, D. Towards a National System of Education in Kenya. In Court, D., and Ghai, D., Education, Society and Development - New Perspectives from Kenya. Nairobi: Oxford University Press, p. 332, 1974.

15. Republic of Kenya. Report of the National Committee on Educational Objectives and Policies. Nairobi: Government Printer, p. 19, 1976.

are objectives which stress the need for education to inculcate skills and attitudes considered necessary for cementing national unity and fostering the country's development. Second, through the introduction of new school subjects, and recasting of content and approaches in the traditional subjects, the curricula attempt to re-orientate learning towards the practical, technical and vocational. Third, there are objectives which imply the development of pedagogical approaches based on a learner's role which is active, nurtures the growth of the whole person and emphasizes problem-solving. In contrast to the earlier curricula, "rote learning and memorisation" are to be replaced by activities which encourage the development of problem- solving skills; through continuous assessment, the influence of facts-dominated and centrally-conducted examinations is to be reduced; the growth of the whole person is to be aimed for through "all round mental, social, moral and spiritual development of the learner" and by ensuring that there is "parity in the cognitive, psychomotor and affective skills" acquired by students (Republic of Kenya 1984).[16]

Societal perceptions of the role of IT in development and attempts at reform of curricula seem to suggest fertile ground in relation to the introduction of computers into the schools of developing countries such as Kenya, and therefore a favourable back-drop to the evaluation of CEPAK. However, such optimism needs to be tempered by the prevailing situation with regard to the financial provision for education. The following paragraphs describe broad financial issues which are later taken into account in discussing CEPAK's costs, and which are important in planning the computerisation of schools in developing countries.

Since the late 1970s, one of the most serious problems facing society and government in developing countries is a severe decline in the financial provision for education (Eicher 1984, Psacharopoulos & Woodhall 1985, Williams 1986, World Bank 1987). For instance, the World Bank observes that in Sub-Saharan Africa the annual growth rate of total public expenditure on education declined from an average of 6.8% during the 1970s decade to -2.9% between 1980 and 1983.[17] The decline in the public provision for education has been most severe in the primary and secondary sectors (Table 1.01).

In most developing countries, including Kenya, the problem of financing education has worsened in the course of the 1980s. According to the World Bank, in Kenya the public recurrent expenditure per secondary student declined from $266 (124% of GNP per capita) in 1970 to $74 (22% of GNP per capita) in 1983. To an extent, in terms of resources available to schools, the decline in public expenditure has been

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16. Republic of Kenya. 8-4-4 System of Education. Nairobi: Government Printer, pp. v, 1, 3 and 5, December 1984.

17. World Bank. Education Policies for Sub-Saharan Africa: Adjustment, Revitalization, and Expansion, Table 14. Washington, D.C., 1987.

Table 1.01. Public Recurrent Expenditure per Student in Sub-Saharan Africa, 1970- 1983 (in 1983 US $).

	1970	1975	1980	1983
Primary student	67	61	51	48
As % of GNP per capita	16%	19%	16%	15%
Secondary student	362	308	195	223
As % of GNP per capita	111%	93%	62%	62%
Tertiary student	2462	3090	2798	2710
As multiple of GNP per capita	11	12	7	8

Source: World Bank. Education Policies for Sub-Saharan Africa: Adjustment, Revitalization, and Expansion. Washington D.C., 1987.

compensated for by increased provision by parents and communities. However, increased parental and communal share in financing education has not fully met the schools' needs (Makau 1987a) and as a consequence, the current development plan (Republic of Kenya 1989) starkly points out that:

> The problem of financing education from the public budget proves to be the most critical issue facing the sector. Although the cost of education is currently borne both by the public and private sectors, the share of public expenditure on education has now become an issue of major concern. As of 1987, over 35 per cent of the total public recurrent budget was taken up by education alone, compared to 15 per cent in the 1960s and 30 per cent in 1980.[18]

Constraints in the financial provision for education - associated with rapidly rising enrolments and failure of revenue to match expenditure demands in public budgets - have important implications for the planning of novel moves, such as computerisation. Because certain costs (such as teacher salaries and students' boarding charges) must be met, in the face of a dwindling allocation for education, expenditure on learning materials (such as textbooks and science equipment) has had to be curtailed. Thus, if schools cannot adequately be provided with what they currently need in way of learning resources, should consideration be given to providing a new and more expensive educational technology? Or are there overriding advantages in computerising schools which justify the additional expenditure?

CEPAK took into account that, given severe constraints in local resources for education, funds for experimentation or research and development of IT as an educational tool were scarce. External funding of the innova-

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18. Republic of Kenya, 1989 (see note 11), pp. 212-213.

tion, together with a research component, provided an invaluable opportunity for Kenya to practically explore and document IT applications which could relevantly lead to higher quality of education in secondary schools. Equally important, systematic study of the innovation provided an opportunity for the collection and analysis of data on the implications of computerising schools in Kenya. Particularly important in this regard was to be data-based documentation of (1) the relationship between outcomes and the costs (both monetary and non- monetary) of computerising schools (2) the extent to which local resources could be mobilised for the introduction of computers into more schools.

As a prelude to describing the structure of CEPAK, a brief description of salient features of the Kenya education system is presented.

SOME FEATURES OF THE KENYA EDUCATION SYSTEM

Prior to 1984, formal general education was organised into four distinct sectors: primary school - 7 years; lower secondary school - 4 years; upper secondary school - 2 years; and university education - at least 3 years. In 1984 the primary school course was extended to 8 years, the two secondary sectors were consolidated into a four year course, and the minimum duration of university education was made 4 years. In reference to the number of years in the three sectors, the new system acquired the title of "The 8-4-4 System of Education." At the secondary level, the 8-4-4 curriculum was introduced in Form 1 in January 1986. Thus, the first cohort of 8-4-4 students is scheduled for university admission in 1990. As compared to the earlier system, the 8-4-4 curriculum requires that students be exposed to more disciplines. For instance, whereas previously a secondary student could concentrate on a minimum of seven subjects at the lower level and a maximum of five at the higher level, under the 8-4-4 system ten subjects must be studied.

An important feature of the education system is the fact that movement from one sector to the next is based on selection in accordance with performance in centrally conducted public examinations. Because places in the secondary and university sectors are limited, progressively smaller proportions of students are admitted into the two sectors. Currently, over 90% of the eligible age group is admitted into primary school. Of those who complete primary school, about 40% are admitted into secondary school. Only about 7% of secondary school granduands are likely to get a place in one of the four national universities.

All secondary school students are required to pay school fees. The amounts paid vary according to the type of school attended. Four different types of schools are identifiable as follows. (1) Government maintained schools receive both capital and recurrent grants from the Ministry of Education (ME). All teachers in maintained schools are public servants paid by the government. (2) Government assisted secondary schools are community institutions which receive some financial assistance (mainly salaries for some or all of their teachers) from ME. (3) There are community schools which receive no financial assistance

from the government. (4) Private schools are institutions founded by individual entrepreneurs or special groups, such as religious bodies. In 1987, there were about half a million students in 2,485 secondary schools; 635 of the schools were government maintained, 1,497 were government-assisted and 353 were unaided community or private schools.

THE STRUCTURE OF PHASE II OF THE PROJECT

Lessons from the Pilot Phase

At the inception of the project, the pilot school was provided with five microcomputers. Initially it was decided that only teachers would work with the computers, with the emphasis being on learning how to operate rather than on learning programming. Playing the role of professional facilitator and technician, the project director encouraged teachers to "play" and explore the classroom software packages (a total of about 80) provided as part of the initial project equipment. In some of the subjects teachers found that there were programs which could be used with students, and several teachers decided to go ahead. The main thrust of the innovation was to effect change in the teaching-learning process through teacher in-service training using the computer as a catalyst. Two external evaluations of the pilot phase found evidence that change had begun to take place in relation to teacher pedagogical perceptions and practices. Relating the experiences of two teachers who, through use of the computers with students, had been led to think out new pedagogical approaches Papagiannis (1985) concluded:

> One of my major findings (and confirmation of findings from previous reports) is that the teachers have become more reflective about their subject-content and their pedagogy used with students. In a sense, one could describe this capacity as an "exploratory attitude" toward the possibilities of computer technology use in the instructional process but more importantly, toward the art and science of teaching itself.[19]

Citing evidence of increased student motivation and active participation in lessons (particularly where grouping was resorted to) associated with use of the computers, Gakuru and Kariuki (1986) concluded that the innovation was beginning to result in the emergence of new relations in the learning environment.

In addition to use of the technology in the normal curriculum, two other developments took place. First, it appeared desirable that a direct computer-related course for students should be developed. Thus an information technology course was introduced, with its basic objective being to give students some ideas of the way the world of information

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19. Papagiannis, G.J. The Nairobi Aga Khan Academy Computers in Education Project - A Review. Geneva: AKF (unpublished report), p. 7, 1985.

might function and impinge on their lives in the future. Second, partly spurred by the desirability of providing a practical example of the use of computers in the work-place, the head of the school decided that the technology should be introduced in the management of the school. Within one year of the launching of the project the school administration had acquired a microcomputer.

Objectives of Phase II

Based on the pilot phase experience, in planning Phase II a clearly defined educational philosophy was articulated. Deviating from the tendency in the developed North for computers in schools to be dominated by courses - such as computer science - which make the technology the object of study, CEPAK sought to introduce the computer as an educational tool which should enhance the quality of learning in the entire curriculum and which should make school management more efficient. In relation to teaching- learning, the computer was seen as a tool which should enable the ordinary subject teacher to conceptualise the content and context of learning in new ways which emphasize active involvement of the learner as well as peer learning among students. The outcome of such emphases was expected to be the stimulation of learning experiences which nurture the growth of creativity, initiative, problem-solving and reasoning skills. In pursuit of the foregoing, the project proposal (Wray 1985) specified the following five objectives:

- to improve the quality of teaching by in-service teacher education using the microcomputer as a catalyst;
- to use microcomputers as a teaching resource in school subject topics of the Kenyan secondary school syllabus;
- to provide the pupils with a basic knowledge of new information technologies, both to aid them in their studies and to make them aware of their technological environment;
- to improve the quality of school administration through the use of appropriate information technology;
- to appoint such members of staff as required so that the school can maintain its level of educational/information technology without the need for continued support from outside.[20]

Three points stand out from the foregoing objectives. First, all sectors of the school, i.e. students and staff (including non-teaching staff), were expected to be influenced by the innovation. Second, in relation to the innovation some members of staff were expected to assume new responsibilities. Third, CEPAK did not altogether set out to abandon the idea of making the technology the object of study: according to the third objective, students were to be exposed to the basics of the technology and were to be made "aware of their technological environment."

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20. Wray, B.F. Computers in Education Project Phase II, 1986-1988 - A Proposal Submitted by the Aga Khan Education Service (Kenya) to the Aga Khan Foundation. Nairobi, p. 1, August 1985.

Profiles of the Schools

Of the six schools in Phase II, three were located in Nairobi, two in the coastal town of Mombasa and one about twenty kilometres northwest of Nakuru in the Rift Valley. Two of the schools were private institutions, three were government-maintained, while the sixth was government-assisted. Table 1.02 shows other particulars of the schools. Throughout this report the six schools are code-named P, Q, R, S, T and U.

Threshold Package Provision

In the planning of CEPAK it was recognised that in an education system characterised by constraints in the financing of education, the issue of the cost of the new technology needed to be addressed. It was felt that experimentation should be based on a threshold package of equipment which, while making the venture viable, could be afforded by some schools in a third world setting. It was decided that the threshold package should include five computers, with one of the computers being earmarked for use by school management while the other four would be made available for teacher and student use. The threshold package was also planned to include a small number of software packages and relevant reading material.

Donor funds were used to provide each of the five new schools with five Apple IIe computers[21] and peripherals. The peripherals included two 12" colour monitors, five 12" monochrome monitors, one 20" colour monitor,

Table 1.02. Particulars of the Schools Studied in Phase II.

School Code	Type of School	Number of Students	Number of Teachers
P	Mixed boarding	630	50
Q	Mixed day	420	30
R	Girls day	760	50
S	Girls boarding	500	38
T	Mixed day	440	42
U	Mixed day	440	35

Notes:
(1) The students' enrolment figures and the numbers of teachers were for 1988.
(2) In the mixed schools, the ratio of boys to girls was 3:1.

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21. Four of the computers were fitted with an English keyboard, with the fifth having a French keyboard. School T does not teach French and subsequently the computer with a French keyboard was replaced with an English keyboard one. Each of the computers had a memory of 128 Kb. In the course of Phase II each school has had one its computers upgraded to at least 512 Kb.

three 5.25" disk drives, five 3.5" disk drives, three Imagewriter II printers, three mice and 2 joysticks.

The evaluation of the pilot phase had revealed that there was heavy usage of the threshold package. Thus, in Phase II it was felt that there was a case for experimentation with a larger package. Donor funds were used to double the equipment in the pilot school (i.e. school U in Table 1.02). Thus, in Phase II school U had available 6 Apple IIe computers (2 with French keyboards), 2 Apple IIGs and 2 BBCs. Peripherals provided to the pilot school included six 12" colour monitors, six 12" monochrome monitors, one 26" colour monitor, ten 5.25" disk drives, eight 3.5" disk drives, six Imagewriter printers, one Dot-matrix printer, one Microline printer, five mice, 2 joysticks, one Robostic and one graphics tablet. Using its own funds, the pilot school also acquired three microcomputers (2 Apple IIe, 1 Apple IIc and peripherals) for purposes of school management.

Taking into account the pilot phase experience, it was decided that the project should make an effort to encourage the classroom use of a variety of tools and not just the computer alone. Thus, in Phase II donor funds were used to furnish school U with a video recorder, a television set, an audio cassette recorder and an overhead projector.

With regard to software, school U was provided with about 270 programs during the pilot phase. During Phase II the school was helped to build its library to 400+ programs, including about 30 developed locally (mainly by the staff of the school). At the beginning of Phase II, a package of software was provided to each new school. As shown in Table 1.03, this nucleus of school-based permanent software libraries was progressively augmented in course of the implementation.

Table 1.03. Software Permanently Kept By Each New Phase II School.

Category of program	At the beginning of of Phase II		In February 1989	
	n	%	n	%
Education (general)	1	8	27	40
Subject-specific	6	46	26	39
Programming languages	1	8	7	10
General applications	2	15	4	6
Graphics	1	8	1	2
Educational games	1	8	1	2
Utilities	1	8	1	2
Total	13	101	67	101

The project also provided the schools with computer consumable stores (e.g. blank disks, printer ribbons and paper) and reading materials (books, magazines and journals) on the use of computers in education. With regard to reading materials, at the beginning of Phase II each of the schools was provided with 30 books, including 16 on information technology, 9 on use of computers in specific subjects, 3 on computer programming and two on pedagogical approaches. Further, in the course of Phase II the schools were regularly supplied with copies of magazines and journals.[22]

The Project Office

At the beginning of the pilot phase a project director (PD), a former physics teacher with knowledge and experience of computers, was hired to steer the innovation. The PD's experience in the pilot phase was instrumental in the decision to expand the project to more schools, and as a consequence he was invited to undertake the implementation of Phase II. To assist the PD, an office manager and three technical assistants were hired. The PD had also access to a secretary employed to work for the research team.

Apart from undertaking the professional implementation of the innovation, the PD had responsibility for the management of project funds, including the administration of local and overseas purchases and maintenance of accounts on petty cash basis. As shown in Part 4, these responsibilities had an important bearing on the PD's allocation of time to various aspects of the implementation of the innovation.

Whereas during the pilot phase the PD had been stationed in the one school in the project, in Phase II it was decided that, in order to make the project office impartial in its dealings with all six schools, a new office should be established in premises which were not part of any of the project schools. Two classrooms at the Aga Khan High School[23] in Nairobi were made available as the Phase II project office.

The project office was established to serve as the innovation's focal point with regard to technical and professional backup. With a well equipped conference room, the office was the forum for centrally organised workshops. Further, it served as the point from which repair and maintenance of equipment were organised, and materials distributed to the schools. An important feature of the office was its library from which schools could borrow reading materials and software. In February 1989, an analysis of the library database revealed that there were 264 titles of books categorised as per Table 1.04.

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22. Magazines distributed to schools included: Compute!, Practical Computing, Computer Education, Electronic Learning, Micromaths and East African Computer News.

23. As part of a further expansion of the project, this school joined the project at the beginning of 1988.

Table 1.04. Books in CEPAK Library, February 1989.

Category	Titles	
	n	%
Specific curriculum disciplines	118	45
Information technology	81	31
Education general	32	12
Programming	18	7
Specific teaching-learning activities	15	6
Total	264	101

In addition, the library regularly obtained copies of a number of international magazines and journals on education and use of IT in education.[24]

An important feature of the library was its collection of both general and subject-specific computer programs. The computer programs in the library in February 1989 are shown in Table 1.05.

Table 1.05. Software in CEPAK Library, February 1989.

Category	Titles	
	n	%
Subject-specific programs	205	59
Education general	36	10
Utilities	32	9
Graphics	31	9
General application programs	21	6
Educational games	12	3
Programming languages	11	3
Total	348	99

24. Among journals and magazines obtained were: The Journal of Curriculum Development, The Journal of School Organization, Education and Training International, Education Media International, Journal of Information Technology, PLET - Journal of the Association for Educational & Training Technology, Journal of Computer Assisted Learning, Information Technology for Development, Byte, Classroom Computer Learning, The Computing Teacher, Computers in Education.

PHASE II RESEARCH COMPONENT

Objectives of the Study

In recognition of the importance of the project's attempt to use IT to develop fresh approaches to educational processes, the International Development Research Centre and the Rockefeller Foundation agreed to join hands with the Aga Khan Foundation to fund systematic research into CEPAK. The research effort was expected to:

(1) decipher and record the extent of changes, associated with the introduction of the technology, which occurred in the teaching-learning transaction and the management of the schools;

(2) study the cost implications of the innovation.

The study was not to be confined to the mere evaluation of the project. In addition to analysing the particulars of the project, the research team was expected to use salient themes to abstract into and make suggestions on (1) the possibilities of replicating the innovation on a wider scale, and (2) the improvement of educational processes in Kenyan schools even if the new technology could not be introduced on a wider scale.

In evaluating the the innovation's impact on the teaching- learning transaction, it was decided that - for reasons discussed at the beginning of Part 3 - improvement in test scores would not be used as a measure of effectiveness.

Research Methodology

Bearing in mind literature to the effect that reality in social phenomena, such as education, is best approached and understood through the simultaneous application of quantitative and qualitative methods (Cook & Reichhardt 1979, Dockrell & Hamilton 1980, Patton 1980, Miles & Huberman 1984, Yin 1984, Bracey 1989), the research team's modus operandi was the collection and analysis of both quantitative and ethnographic data.

In planning the study, two important factors were recognised. First, it was recognised that the research team needed easy access to equipment and materials in the project office. Second, the researchers needed to have a working knowledge of computers. To meet these needs three measures were taken. First, it was decided that the research team would be housed in the project office and would have access to the project hardware, software and reading materials. Second, the research team was provided with a research station, equipped with an IBM compatible 512Kb hard disk microcomputer and software programs (such as **SPSS**, **Dbase III+**, **Lotus 1-2-3**, **Procite** and **Microsoft Word**) and a budget for the acquisition of literature on computers in education. Third, as a condition for participating in the study, the researchers undertook to master the equipment both in the research station and in the project.

A significant feature of the study was the fact that three researchers were involved. This set-up called for careful collaboration in planning and carrying out activities - such as data collection and analysis, and report writing. From the start, the research team established four collaborative approaches. First, it was decided that once every month the team would hold a formal meeting, with minutes being kept, to (a) share ideas on education and research methodology (b) review progress of the study to date (c) plan in detail the activities for the following month. Second, all drafts of written research instruments were thoroughly discussed and revised by the team before being administered. Third, after a bout of observations and interviews by a researcher, he or she was required to prepare a detailed field report. Copies of the word-processed report would then be distributed to the other researchers. After all the researchers had read the report, the team would then meet and discuss the salient points. Statistical data was given a similar treatment: one researcher would undertake data entry into and analysis by the research computer; he or she would then prepare a draft for discussion by the team. Fourth, with regard to the preparation of professional reports for submission to the funding agencies, the research team decided that, on alternate basis, one researcher would prepare a first draft. The draft would then be read by the other two and subjected to discussion by the team; the draft would then be revised and finalised by the research director.

At the initial stages the research team, which launched the study at the beginning of July 1986, concentrated on collecting and analysing data to establish the schools' baseline status at the beginning of Phase II. Data was analysed from the following sources (1) data collected during the evaluation of the pilot phase (2) survey data obtained through written questionnaires administered to teachers and students in the five new schools (3) verbal interviews of headteachers and a selection of subject teachers (4) school documents - such as school magazines, student admission letters and school regulations (5) observation of 218 lessons covering all subjects in the schools' curricula. A baseline report (Makau 1987b) was prepared and submitted to the funding agencies.

Subsequent to the establishment of the baseline status, the research activity consisted in: (1) observations and interviews at all CEPAK-organised workshops (2) observation of lessons (91 were observed, 65 were computer-assisted) (3) interviews as follows: 104 with 100 students, 276 with 148 teachers, and 21 with 16 non-teaching staff (4) observations at meetings of school computer clubs (5) examination of school records on the use of the computers (booking systems on the use of computer rooms, records of software and reading materials, teacher/student computer files and printed products, and school management documents such as notices, correspondence and accounts records) (6) analysis of CEPAK's central library records (7) evaluation of software (8) examination of the project's accounts records (9) interviews and discussions with the PD and the technical assistants (10) analysis of data collected through student and teacher questionnaires administered in the third term of 1988 (11) dissemination and discussion of project ideas and interim research findings at national and international forums.

A crucial aspect of the study was report writing. The research proposal specified that each quarter the research team would select an aspect of the project and prepare a professional report for submission to the funding agencies. In the course of Phase II, 8 quarterly reports were submitted.[25] In addition to enabling the research team to attempt a formative role in the implementation of the project, the quarterly reports proved to be an excellent way of forcing the researchers to relate interim findings to the research proposal and thereby give advance thought to the structure and ideas in this final report.

The Baseline and 1988 Survey Samples

As indicated in the previous section, two sets of written questionnaires were administered to teachers and students in 1986 and 1988. It was decided that the baseline questionnaires would not be administered in school U since the evaluations of the pilot phase contained information which appeared to be a sufficient base for comparisons with developments in Phase II. However, this decision meant that the baseline statistical data obtained from the new Phase II schools was not matched with corresponding data from the pilot school.

The number of teachers who responded to the 1986 (baseline) and 1988 questionnaires are shown in Table 1.06.

In the baseline sample, the 170 respondents represented about 90% of the total number of teachers in the five new schools, while the 110 respondents in the 1988 survey represented about 45% of the total teacher establishment in the six schools. In the 1988 survey the per school proportions of the establishment who filled the questionnaire were: U - 71%, R - 46%, P - 45%, Q - 43%, T - 36% and S - 32%. It should be noted that overall the proportion of respondents to the 1988 questionnaire constituted half of the proportion of the establishment who had filled the baseline questionnaire. This difference in rate of response to the

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25. Copies of interim reports could be obtained with the permission of AKF (Geneva). The following interim reports were prepared:

Makau, B.M. Report for the period, July to mid-November 1986 (10pp.), November 1986.

The First Six Months of Implementation of Phase II of the Computers in Education Project: Emerging Status of the Innovation in the New Five Schools (20pp.), May 1987.

The Status of the Innovation in Six Schools (28pp.), September 1987.

Successes and Shortcomings During the First Year of Phase II (34pp.), December 1987.

Aspects of Teacher Resistance to the Innovation and Its Relationship to the Implementation Strategy (32pp.), March 1988.

Towards a Cost-effectiveness of the Project (31pp.), June 1988.

Students' Reaction to the Use of the Computer as a Learning Tool - Analysis of Data from the Aga Khan Academy (41pp.), September 1988.

Teacher Use of Computers and Attitudes Towards the Technology (37pp.), January 1989.

Table 1.06. Number of Teachers Responding to Written Questionnaires.

School	Baseline	1988 Survey
P	35	22
Q	22	13
R	40	23
S	35	12
T	38	15
U		25
Total	170	110

two surveys to an extent reflects the nature of the two surveys. The baseline questionnaire elicited answers to questions on pre-innovation teaching and learning approaches, as well as generalised knowledge of and attitudes towards computers. Thus, it would appear that most of the teachers felt that they could intelligently attempt to answer the questions. A further reason for the high rate of response to the baseline questionnaire was probably the excitement created by the prospect of exposure (as yet undefined in mid-1986) to the new technology. In contrast to the baseline study, most of questions in the 1988 survey could only be answered by teachers who had made an attempt to adopt the technology. Thus, it is not surprising that in the pilot school where the majority of the staff had some knowledge and experience of the innovation, 71% of the establishments (as compared to less than 50% in the new schools) responded. The comparatively low rate of response in the new schools may also have partly resulted from flaws in the actual administration. However, it should be noted that in each school the questionnaire was personally administered by a researcher. In spite of prompting by the school heads, most teachers were observed to be unwilling to respond, most likely because they lacked the necessary knowledge. Thus, it would appear that most of the teachers who did not respond to the survey had had little or no interest in exposure to the technology. In the first section of Part 3, teachers' responses to a number of items are presented as proportions of the total number of teachers in the schools, the idea being that the approach gives a measure of the innovation's extent of success. The strong probability that the respondents largely represented teachers who had adopted the technology would seem to justify such an interpretation.

The number of students who responded to the 1986 and 1988 questionnaires are shown in Table 1.07.

In the baseline survey, the questionnaire was administered to students in Forms 1, 3 & 5. Because of the change-over to the 8-4-4 system, in 1986 there was no Form 2 class in secondary schools. One of the purposes of carrying out the survey was to identify a number of informants who could be studied during most of Phase II. Thus, with regard to Form 4 and 6, it was decided that since the students were completing their courses at

Table 1.07. Number of Students Responding to Written Questionnaires.

School	Baseline	1988 Survey
P	336	570
Q	223	325
R	382	705
S	306	481
T	288	157
U		433
Total	1535	2671

the end of 1986, there was little point in including them in the survey. The number of respondents represented about 54% of the total student enrolment.

In the 1988 survey the questionnaire was administered to students in all classes in the schools. Since there had not been a Form 2 class in 1986, there was no Form 4 in 1988. For the six schools, 84% of the enrolment responded to the questionnaire. The proportions for individual schools were: U - 98%, S - 96%, R - 93%, P - 91%, Q - 77% and T - 36%. The relatively low proportion of respondents in school T was due to the fact that the teacher who administered the questionnaire decided to give copies only to students who had some experience with the computers. This flaw in the administration created problems in relation to inter-school statistical comparisons based on the 1988 survey. In subsequent sections of this report, relevant weaknesses in school T's data are pointed out.

Use of Names in Ethnographic Data

Where in Parts 3 and 4 informants or subjects of observation are identified as particular individuals, pseudonyms are used. In the case of students, the actual first names are used.

In Part 2, the report deals with the human resource input into the innovation at the school level, the implementation philosophy and the actual approaches taken in seeking to achieve the project's objectives.

PART 2

IMPLEMENTATION OF THE INNOVATION

THE HUMAN RESOURCE INPUT AT THE SCHOOL LEVEL

An understanding of some of the basic characteristics of teacher and student populations in the project is an essential back-drop to a discussion of the innovation's philosophy and strategies employed in implementing it. First, such understanding should help place the innovation in the wider context of Kenya's social development, especially as it relates to secondary education. Second, the pre-innovation characteristics of the two populations should be seen as having a bearing on the implementation in that they constituted the condition which the project set out to act upon. In this sense, such aspects as the teachers' qualifications and work loads, the two populations' exposure to technology, and the students' socio-economic background could be seen as factors which may have influenced the implementation of the project.

The profiles of the two populations are based on the analyses of data collected in the baseline and 1988 surveys.

Profile of the Teachers

Table 2.01 shows the number and gender of teachers in the two samples. The two questionnaires required the teachers to indicate their ages. Data obtained from analyses of the two samples are presented side by side, with the data from the 1988 survey being shown in brackets against the baseline data. The ages of the teachers ranged from 23 to 58 (24 to 58) with a mean of 34 (37) and a median of 33 (36).

Table 2.01. Teachers in the Project by School and Gender.

School	Number of Teachers (%s in brackets)			
	Baseline		1988 Survey	
	Female	Male	Female	Male
P	9 (26)	25 (74)	8 (36)	14 (64)
Q	6 (27)	16 (73)	3 (23)	10 (77)
R	30 (77)	9 (23)	19 (83)	4 (17)
S	32 (91)	3 (9)	10 (83)	2 (17)
T	27 (71)	11 (29)	12 (86)	2 (14)
U			10 (40)	15 (60)
Total	104 (62)	64 (38)	62 (57)	47 (43)

Although in the baseline sample there were citizens of ten different nations, the great majority of the teachers were citizens of Kenya: there were 124 (73%) Kenyans, 17 (10%) Indians, 12 (7%) Ugandans, 9 (5%) British citizens, 3 (2%) Tanzanians, and 5 (3%) others. In the course of Phase II these proportions did not change much. Thus the innovation should be regarded as having been principally planned for the development of school staff who are Kenya citizens.

The data in Table 2.02 gives an indication of the academic qualifications of teachers in the project.

Table 2.02. Qualifications of Teachers in the Project.

	Number of Teachers (%s in brackets)			
	Baseline		1988 Survey	
School	Graduate	Other	Graduate	Other
P	30 (86)	5 (14)	20 (91)	2 (9)
Q	21 (95)	1 (5)	13 (100)	
R	19 (47)	21 (53)	13 (59)	9 (41)
S	22 (63)	13 (37)	6 (67)	3 (33)
T	18 (47)	20 (53)	9 (69)	4 (31)
U			19 (90)	2 (10)
Total	110 (65)	60 (35)	80 (80)	20 (20)

Note: Graduate = teacher with a university degree.

With regard to the whole sample, the majority of teachers were university graduates. To the extent that university education disposes the beneficiary to readily adapt to change, it would seem that the academic qualifications of most of the teachers were a facilitating factor in the implementation of the computer innovation. Other data obtained from the samples suggest that there were three other facilitating factors. First, most of the teachers in the project schools were professionally qualified. In both the baseline and the 1988 samples, 82% of the teachers had undergone formal teacher training, an indication that they were not altogether unaware of the pedagogical approaches advocated in the computer innovation. Second, there was a positive relationship between the subjects studied in college or university and the school disciplines taught by most teachers. According to the baseline data, 85% of the teachers were teaching subjects which they had studied in their pre-teaching courses. Thus, it would seem that in CEPAK these teachers had the option to spend most time in developing the new teaching approaches, rather than in acquiring the academic knowledge needed by their students. Third, the majority of teachers had work loads which were below average. Table 2.03 shows the weekly teaching loads in the baseline sample.

Table 2.03. Teaching Loads in the Baseline Sample by School.

Periods/Week	Percentages of Respondents					
	P	Q	R	S	T	Average
<10	6		5	3	11	5
10-14	3	9	3	9	34	12
15-19	11	5	24	40	42	32
20-24	34	29	58	48	8	36
25-29	46	38	10		5	12
>30	19					2
Total	100	100	100	100	100	99
N	35	21	38	35	38	167
Mean	22.4	23.5	18.8	18.8	14.8	19.3
S.D.	6.113	7.584	6.355	3.454	4.842	6.358

Each period was 40 minutes long and a teaching day consisted of 9 periods, thus the maximum, possible weekly teaching load was 45. Interviews with the heads of the schools and and information obtained from school inspectors indicated that for the ordinary teacher, a weekly load of between 25 and 30 periods was considered normal. With below average teaching loads, it would seem that the teachers in CEPAK had time which they could devote to developing use of the computer as a teaching and learning tool.

The foregoing factors seemingly poised to facilitate the innovation were counterbalanced by three inhibiting teacher characteristics. First, the work experience of most of the teachers was limited to secondary school teaching: according to the baseline data, only 23 (14%), 8 (5%) and 5 (3%) respectively had taught in primary schools, teachers colleges and other educational institutions. Thus, most of the teachers lacked any non-secondary teaching experience which may have been beneficial to the ideas of the project. Second, data on length of teaching experience in various schools indicated a rapid teacher turn-over, which could inhibit the systematic development of the innovation. The mean number of schools taught in by the baseline sample was three, while the proportions of respondents falling within specified ranges of years in teaching were as follows: 1 to 6 years - 35%; 7 to 12 years - 35%; 13 to 18 years - 17%; 19 years and over - 13%. Data from the 1988 survey indicated that the situation had not changed significantly since the baseline survey. The teaching experience of the 1988 sample ranged from 1 to 34 years, with a mean of 11.24 and a standard deviation of 7.49. Length of service in the current school ranged from 1 to 24 years, with a mean of 6.45 and a standard deviation of 5.19. The clearest indication of rapid turnover was the finding that, of the teachers surveyed in 1988, 38% had joined their current schools after Phase II had started. Third, the great majority of the teachers neither had prior exposure to computers nor, in

the course of Phase II, did they have access to the technology outside the project schools. Teachers with prior or external exposure to computers (at college, at home, or elsewhere outside the project) could be deemed to have brought into the project an experience which would facilitate the implementation. Data obtained from the baseline and 1988 surveys indicated that only a small proportion of the teachers had such experience. Of the 110 teachers responding to the 1988 questionnaire, only 13 (11.8%) responded that they had used a computer during their teacher training courses. The responses of teachers who had opportunities to work with computers outside the project, owned or had access to a home computer are analysed in Table 2.04.

The limited exposure to the technology indicated by the foregoing data meant that the implementation of CEPAK was virtually taking place on virgin ground. Thus, the implementation needed to help the majority of school staff to (a) overcome anxiety over the technology, (b) learn the technical operations of the computer, (c) begin to use the new tool in their work as teachers and managers.

Profile of the Students

According to the baseline survey, the ages of the students were in the range of 13 to 23 years. Table 2.05 shows the mean age of the students by school and form level.

Apart from the great majority (98%) of Kenya citizens in the students' sample, seven other nations were represented as follows: Britain - 9; India - 6; Tanzania and Uganda - 3 each; USA - 2; Denmark and Sri Lanka - 1 each.

Some of the baseline data was aimed at finding out the extent to which the sample represented various Kenyan communities, and thus how widespread the beneficial outcomes of the computer innovation were likely to be. The students were asked to indicate their provinces and districts of origin. Table 2.06 shows an analysis of the responses of the 1,456 students who indicated their provinces of origin.

Table 2.04. Exposure to Computers Outside the Project.

	Number of Teachers	
	Baseline n = 170	1988 Survey n = 110
Have used a computer outside the project	12 (7.1%)	16 (14.5%)
Owns/has access to a computer at home	6 (3.5%)	5 (4.5%)

Table 2.05. Mean Age of Students in the Baseline Sample.

Form	P	Q	R	S	T
1	14.9	14.7	15.3	14.4	15.0
2	16.3	15.4	16.3	15.3	15.9
5	18.7	17.1	17.9	17.2	18.0

Table 2.06. Students' Province of Origin by School.

	Percentages of Students							
	COAST	CENTRAL	EAST	NBI	RIFT	WEST	NYANZA	NEAST
P	3.6	9.0	9.3	0.3	57.4	6.0	13.5	0.9
Q	87.6	1.8	4.1	1.4	0.9	1.4	2.8	
R	67.8	5.8	4.2		0.6	10.1	11.5	
S	5.2	38.3	10.8	15.6	6.9	8.3	14.6	0.3
T	1.5	29.6	11.1	1.9	3.1	19.5	32.9	0.4
Average	31.8	16.6	7.9	3.7	15.3	9.2	15.2	0.3

Abbreviations of Names of Provinces: EAST = Eastern; NBI = Nairobi; RIFT = Rift Valley; WEST = Western; NEAST = North Eastern.

Although the provincial distribution of students in Table 2.06 does not correspond to the provincial distribution of the population of Kenya (Republic of Kenya 1979)[1], it is significant that all eight provinces were represented in the sample. The wide representation of various parts and communities of the country was confirmed by data on the students' districts of origin. Each of the eight provinces is divided into a number of districts, each of which roughly constitutes the home area of one or more of the country's ethnic communities. Altogether Kenya has 42 districts. Analysis of the students' districts of origin revealed that only one district, Garissa in the North-Eastern Province, was not represented in the sample and only five districts were represented in only one of the schools.

An important observation on the data in Table 2.06 should be noted. Although schools Q, R, S, and T are in Nairobi and Mombasa and most likely many of their students had parents working or living in the two urban areas, according to the students' enrolments, these schools tended

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1. Republic of Kenya. Kenya Population Census, 1979. Central Bureau of Statistics. The provincial proportions of Kenya's population were: Rift Valley - 21.1%; Eastern - 17.8%; Nyanza - 17.3%; Central - 15.3%; Western - 12.0%; Coast - 8.8%; Nairobi - 5.4% and North Eastern - 2.4%.

to be cross-sections of the whole nation. This finding points to the subtle but real phenomenon that many Kenyan urban dwellers continue to identify themselves with rural communities as their "roots". Even though the students may have lived in Nairobi or Mombasa and though their parents may have had jobs and property in the towns, the majority still regarded their parents' districts and provinces of origin as their homes. In relation to CEPAK, it could be argued that the "rural roots" phenomenon was likely to facilitate the dissemination of the benefits of the innovation to most communities in the country. Equally important, it could also be argued that because the schools in the project brought together students from various cultural and ethnic backgrounds, to the extent that the computer innovation was a contribution to national unification, CEPAK set out to enhance the "nationalising" effect of secondary education in Kenya.

In relation to the students' socio-economic status, three variables - parents' formal education, indicators of material possessions and family size - for which data was collected through the baseline questionnaire are discussed.

The levels of formal education attained by the parents of the students in the sample are shown in Tables 2.07 and 2.08.

It is evident from the data in the two tables that, for all schools, the students' fathers had higher educational attainments than the mothers. Overall, 61% of fathers as compared to 42% of mothers had some education beyond primary school; at the bottom end, 20% of mothers as compared to 12% of fathers had no formal education. These data would seem to indicate that, since mothers take more responsibility for the up-bringing of children, a considerable proportion of the students lacked enlightened home support in relation to the use of the computer as a learning resource. Lack of enlightened home support would also seem to have been aggravated by the fact that 57% of mothers and 49% of the fathers had either no formal education or had attended primary school only. In a situation where, for most students, home support for the computer

Table 2.07. Fathers' Level of Formal Education by School.

Education Level	Percentages of Students					
	P n=313	Q n=172	R n=275	S n=230	T n=203	Total n=1193
University	12	27	8	36	7	17
Form 5-6	4	19	12	22	12	13
Form 3-4	18	33	23	27	28	25
Form 1-2	7	5	6	3	9	6
Full Primary	12	8	18	9	25	14
Some Primary	23	5	17	1	13	13
None	24	3	16	2	6	12

Table 2.08. Mothers' Level of Formal Education by School.

Education Level	Percentages of Students					
	P n=307	Q n=167	R n=295	S n=236	T n=209	Total n=1214
University	3	11	2	13	1	5
Form 5-6	4	14	3	15	5	7
Form 3-4	13	35	16	35	28	24
Form 1-2	5	7	6	8	6	6
Full Primary	13	18	21	17	24	18
Some Primary	25	7	22	7	27	19
None	37	8	30	5	8	20

innovation was either diffuse or lacking, the acceptance of the new learning approaches was likely to be dependent on the successful dissemination of the project ideas through the school staff.

In order to gauge both the economic status of the families and the level of adoption of modern technology, the students were asked to indicate whether or not their families possessed a radio, a television set, a bicycle, a car, a lorry and a tractor. Table 2.09 shows the proportions of families who owned a radio and a television set.

A radio and a television were respectively owned by 90% and 55% of all families. These data indicate that, significant proportions of the students had some exposure to modern communication technology. Thus, to the extent that there are similarities between, on one hand radio and television and on the other the computer, the innovation was not breaking completely new ground. However, exposure to radio and television at home could not be regarded as tantamount to their acceptance as learning resources at school: an important aspect of acceptance - thus acting as a facilitator for the computer innovation - was the extent to which the schools had integrated the two technologies in the processes of organised learning.

The responses on families who owned various items were cross- tabulated. Table 2.10 shows the proportions of families who owned a combination of items.

Table 2.09. Percentages of Families Owning Radio & Television.

	P n=336	Q n=223	R n=382	S n=306	T n=288	Total n=1535
Radio	80	98	88	98	93	90
Television	21	46	50	78	46	55

Table 2.10. Percentages of Families Owning a Combination of Items.

Items	P n=336	Q n=223	R n=382	S n=306	T n=288	Total n=1535
Radio & TV	21	95	50	78	46	50
Radio & Car	21	91	27	67	27	38
Radio & Bicycle	36	66	29	36	29	30
Bicycle & Car	11	64	11	29	9	19
Car & Lorry	4	14	3	5		4
Car & Tractor	5	8	1	6	2	3

Bearing in mind that, with the exception of the radio, the items in Table 2.10 are expensive and thus are beyond the financial means of most Kenyan households (House & Killick 1979)[2], it can be deduced from the data in the table that most of the students in the project schools came from families with above average incomes. A lorry and a tractor are very expensive items and their possession alone or in combination with a car indicates a high level of affluence. Thus, it was most likely that the 4% of families who owned a car and a lorry belonged to an income group at or near the top of Kenya society. The finding that most families with children in the project schools represented the wealthier sectors of the society did not necessarily mean that these schools were more elitist than others. There is research evidence that in Kenya and other third world countries groups with higher socio-economic status are much better represented in secondary education than is the case for the majority of the population whose incomes are relatively low (Weis 1979, Mingat & Jee-Peng Tan 1984, Mingat & Psacharopoulos 1985, Makau 1987). With reference to Kenya in the mid-1980s, Makau (1987) presents evidence to the effect that, because the parental expenses of educating a secondary school student were higher than GNP per capita, "children of the poor are kept away from secondary education."[3]

The data in Table 2.10 indicate that there were differences between schools in relation to the affluence of the students' families. On a scale based on the magnitude of affluence the schools fall in the ascending order P, T, R, S, Q. The ranking of the schools on the basis

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2. House, W.J. & Killick, T. Social Justice and Development Policy in Kenya's Rural Economy - A Survey. University of Nairobi, 1979. They argued that "...nearly 50% of those in the rural economy receive average household incomes of K#100 per annum or less. In addition, of the 1.42 million smallholder households (which comprise 80% of the total Kenya population), 44% earn average incomes of less than K#100 and a further 51% average #250 per annum." - p. 17.

3. Makau, B.M. The Management and Financing of Secondary Education in Kenya - The Effectiveness of Policy at the School Level. University of Nairobi: IDS, pp. 56-57, 1987.

of affluence and parents' education (Tables 2.07 & 2.08) bear a close resemblance: in both cases schools Q and S have more better educated and richer parents than the other three schools. When family size is considered, the school rank order reveals the same trend as for parents' education and affluence. In Table 2.11 the responses of 1,458 students in the baseline sample have been grouped in intervals to indicate the number of children per family.

For the whole sample, family size was large: 68% of the students were from families with five or more children. However, there were significant differences between schools. The proportions of families with five or more children were in the following order: P - 85%; R - 76%; T - 75%; S - 62% and Q - 19%. Families with children in School Q clearly stand out as belonging to a sector of society which was convinced that there is merit in having a small family. In this sense School S came next, but as a distant second.

In summary, it would seem that schools Q and S served groups with high socio-economic status, with a prevalence of professionals, large scale businessmen and middle-higher level workers in the modern sector of the economy. Schools P, R and T - whose clientele had less education and lower incomes, and was characterised by large families - would seem to have served mainly small scale farmers and traders, and lower-middle level workers in the public and private sectors of the economy.

The students' exposure to computers outside CEPAK was limited. Table 2.12 shows the proportions of families who owned a home computer.

Table 2.11. Family Size in the Students' Baseline Sample.

Number of Children	Number of Students (%s in brackets)					
	P	Q	R	S	T	Total
1 - 4	40 (12)	160 (81)	87 (24)	112 (38)	66 (25)	465 (32)
5 - 8	182 (55)	30 (15)	211 (57)	148 (50)	157 (58)	728 (50)
9 - 12	98 (30)	6 (3)	63 (17)	36 (12)	41 (15)	244 (17)
>13	9 (3)	1 (1)	6 (2)	1 (0)	4 (2)	21 (1)

Table 2.12. Percentages of Families Owning a Home Computer.

	Baseline	1988 Survey
P	3.3	2.5
Q	15.8	15.7
R	1.3	0.6
S	13.4	2.9
T	0.4	1.9
U		20.1
Average	5.9	6.5

The data in Table 2.12 indicate that, as in the case of the teachers, the project had a major task of introducing the majority of students to the technology from scratch.

PHILOSOPHY OF THE INNOVATION

Teacher Development as the Basis of Higher Quality Learning

Central to the planning and implementation of CEPAK was the belief that to make learning an active, child-centred and meaningful process which relates to life in the wider society, it is necessary for teachers to be helped to develop new pedagogical perceptions and approaches. In expressing this belief, the conceptualisation of the project sought to (1) approach the problem of teacher quality and the need for in-service education from a wide perspective (2) develop fundamental changes in the professional thinking and practice of teachers and thus go beyond mere introduction of the technology in the traditional teaching- learning situation.

In identifying teacher in-service education as the centre piece of the implementation, the project proposal (Wray 1985) associated low quality education in developing countries with inappropriate teacher development:

> In developing countries a major factor in the poor quality of real education has been the necessarily low priority on teacher development. Teacher preparation is inadequate in numbers, frequently of poor quality and in-service training has been minimal. This leaves whole schools from Headmaster to the newest teacher locked into a never-varying pattern of lecturing and note-taking.[4]

The assertion that poor teacher quality is a problem in many countries and that it adversely affects student learning has abundant support in the literature. The 1980 World Bank Education Sector Policy Paper characterises the issue as follows:

> Despite the known effects of teachers on educational efficiency, most developing countries keep a high proportion of unqualified teachers, and have poorly designed and equipped teacher-training programs and ad hoc in-service training programs.[5]

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4. Wray, B.F. Computers in Education Project Phase II, 1986-1988 - A Proposal Submitted by the Aga Khan Education Service (Kenya) to the Aga Khan Foundation. Nairobi, p. 1, August 1985.

5. World Bank. Education Sector Policy Paper. Washington, D.C., p. 35, 1980.

With reference to a World Bank-commissioned review of teacher effectiveness studies in developing countries, Psacharopoulos & Woodhall (1985) point out that

> After examining thirty-two studies, the review concluded that trained teachers do make a difference, and in particular that teacher qualifications, experience, and amount of education and knowledge are positively related to student achievement.[6]

Although when education systems in the South are compared with those in the North there are differences in the degree and nature of poor teacher quality, there is evidence that developed countries have by no means been able to successfully tackle the problem (Sirotnik 1983, Goodlad 1984, Van Scotter 1985, Nelsen 1985, Dillon 1986, Strahan 1986). Reporting findings of a study based on classroom observations in American schools, Sirotnik highlights the continued teacher-domination of formal lessons as follows:

> Consider the modal classroom picture presented here: a lot of teacher talk and a lot of student listening, unless students are responding to teachers's questions or working on written assignments; almost invariably closed and factual questions; little corrective feedback and no guidance; and predominantly total class instructional configuration around traditional activities - all in a virtually affectless environment. It is but a short inferential leap to suggest that we are implicitly teaching dependence upon authority, linear thinking, passive involvements, and hands-off learning.[7]

Among educational planners and scholars in Kenya, there has been agreement that teacher quality is crucial to the improvement of education at all levels. Summing up the general belief among educational planners, the National Committee on Educational Objectives and Policies (Republic of Kenya 1976) found "that no matter how education is viewed, the role and quality of teachers must be given the most critical consideration if the problems related to education and training are to diminish rather than increase with time."[8] In discussing Kenya-based research data on the importance of teacher quality in the development of cognitive skills among learners, Makau & Somerset (1980) contrast two types of teachers as follows:

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6. Psacharopoulos, G. & Woodhall, M. Education for Development: An Analysis of Investment Choices. Oxford University Press, p. 220, 1985.

7. Sirotnik, K.A. What You See is What You Get - Consistency, Persistency and Mediocrity in Classrooms. Havard Educational Review 53.1, p. 29, 1983.

8. Republic of Kenya. Report of the National Committee on Educational Objectives and Policies. Nairobi: Government Printer, p. 106, 1976.

> Far from being relatively immune to the effects of teaching quality, reasoning ability and to some extent other higher level intellectual skills are particularly prone to such effects. A skilled teacher tries to make facts understandable to his pupils by planning them in a context of cause-and-effect linkages. He tries to show the pupils how to create these linkages for themselves through reasoning... Weak teachers, by contrast, specialise in teaching isolated facts. In subjects such as science, history and geography they copy from a textbook onto the blackboard catalogues of names, dates, places and definitions, which the children reproduce in their exercise books and learn by heart.[9]

CEPAK's emphasis on the need to improve teacher quality through in-service education had support from teachers in the five new Phase II schools. Assuming that regular professional interaction between teachers and school inspectors constitutes an important aspect of in-service education, on a continuum of five boxes the teachers in the baseline sample were asked to indicate their feelings about the effectiveness of contacts with school inspectors. Table 2.13 shows an analysis of the data from 158 teachers who responded to the item.

With only 10% of the sample convinced that visits by inspectors were regularly useful, the data in Table 2.13 suggests that the inspectorate was not giving teachers adequate on-the-job training. The survey data was corroborated in the baseline verbal interviews with the heads of the schools. For instance, the heads of Schools R, S and T maintained that professionally formative inspections were rare and that the few visits by inspectors were connected with either administrative issues or the possible promotion of individual teachers and the selection of schools for the presidential award for merit. Kenya-based research contains

Table 2.13. Teachers' Rating of the Usefulness of Inspectors as a Source of Professional Enrichment.

n = 158

	Percentages of Teachers				
	Regularly Helpful 1	2	3	4	Rarely Helpful 5
Visits to your school by school inspectors	10	20	29	23	18

9. Makau, B.M. & Somerset, H.C.A. Primary School Leaving Examination, Basic Intellectual Skills and Equity: Some Evidence From Kenya. University of Nairobi: IDS Discussion Paper No. 271, pp. 20-21, 1980.

further corroboration. Makau (1987) found that, because of the rapid increase in the number of educational institutions and constraints within the public budget, school inspectors, provincial and district education officers were able to organise only occasional professional interaction with teachers and only for a small proportion of secondary schools.[10]

Through in-service teacher education, CEPAK sought to develop a new type of teacher, one who would motivate students through use of a variety of pedagogical approaches (in particular those based on students' active involvement in learning activities). To underscore this approach to teacher development, the project proposal stated that the emphasis in workshops for teachers "will be the discussion of various educational techniques, not only those directly related to the microcomputers. A determined attempt will be made to re-introduce play, not only when trying out new software, but also by role-playing simulation."[11]

The project planning addressed the issue of how the computer could be introduced such that it had a powerful catalytic effect on teacher pedagogical perceptions and practice. It was recognised that "providing teachers with tools, even powerful ones, <u>without proper education in their use</u> is wasteful" (Wray 1985).[12] Given the newness of the technology and widespread computerphobia (Landles 1987, Marsh 1987, Bracey 1988)[13], the implementation of CEPAK was planned such that part of the in-service education of school staff would be devoted to technical operations and aspects which are in essence part of computer science. For instance, according to the project proposal, out of a total of 186 days planned for in-service workshops for staff in the Nairobi schools 69 (37%) were earmarked for the following aspects: IT - 13, practical operations - 4, programming in PILOT - 23, programming in PASCAL - 5, and LOGO and mathematics - 24. CEPAK's stand that the educational uses of the technology can only be successfully developed if teachers know how to operate the computer has wide support in the literature. For instance, Lally (1989) points out that

> ... it is generally agreed that the single most important factor for the successful use of informatics in education is

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10. Makau, B.M., 1987 (see note 3) - pp. 85-95.

11. Wray, B.F., 1985 (see note 4), p. 13.

12. Wray, B.F., 1985 (see note 4), p. 1.

13. Landles, E. Information Technology and People: The Challenge of Change. <u>The Journal of Information Technology</u> 2.2, 1987.
Marsh, T. Computers in Education. <u>Educational Media International</u> 24.3, 1987.
Bracey, G.W. Still Anxiety Among Educators Over Computers. <u>Electronic Learning</u> 7.1, 1988. With reference to American teachers, he asserts that, "People are still anxious about computers and the most effective in-service programs will take that anxiety into account." - p. 20.

> the building up of a body of teachers who are skilled, confident and innovative in the use of information and communication technologies in education.[14]

Exploration and Discovery: Approach to Teacher Development

The implementation of the innovation was based on the idea that the project should attempt teacher education as opposed to teacher training. According to the the PD, 'attempting teacher education/avoiding teacher training' implied minimising didactic approaches and avoiding spoon-feeding in conducting in-service activities. The PD attempted to play the role of advisor and facilitator, rather than trainer: by exposing teachers to both the technical aspects and educational implications of computers, he expected them to develop new pedagogical concepts and approaches. Rather than relying on didactic 'telling' by an expert, the PD aimed at guiding the teachers to 'discover' for themselves. In a recent paper (Wray 1988) the PD elaborates on this strategy as follows:

> The teachers were to be challenged to work out their own methods of incorporating (the computer) into their teaching and to experience for themselves the sense of discovery and joy in learning which many had lost. The implementation would focus on providing this expanding challenge, providing the means to discover answers and the guidance which would minimise, but not eliminate mistakes. The path was, and is, left deliberately open, not only because there still appears to be no best approach to computers in education, but because most teaching seems directed at giving the 'correct' answer even when it is obvious that none exists.[15]

Discovery was visualised by the PD as a process which should become part of the teachers' pedagogical perceptions and practices, a process which should enable the teacher to regard the search for new knowledge as a life-long engagement. With reference to the computer project, Wray (1987) argued that currently the innovation "is in the learning stage, and it is hoped that it will never grow completely out of that stage", further, that the success of the innovation is not to be determined "by a certain required outcome, but rather by a growth of both the people and the system which they are within."[16]

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14. Lally, M. Training Teachers and Trainers. Paper presented at a UNESCO conference on Education and Informatics, p. 7, April 1989.

15. Wray, B.F. Computers as a Catalyst for Educational Change. Paper presented at the 5th International Conference on Technology and Education. Edinburgh, p. 2, March, 1988.

16. Wray, B.F. Appropriate Introduction of Educational Technology: A Possible Response to the Dilemmas facing Educational Policy Makers in a New Information Technology Age. Paper presented at the VI World Congress of Comparative Education. Rio de Janeiro, p. 16, July 1987.

Advocacy of the implementation strategy was based on two assumptions. First, that when learning takes place under conditions which allow the student - in this case the teacher - to freely explore and discover for himself or herself, the outcome is deep-seated and long-lasting internalisation of knowledge. Second, that the staff in the project schools were favourably disposed to this learning mode and would readily embrace the innovative ideas of the project. In expounding the second of the two assumptions, the project proposal visualised the role of the staff in the new Phase II schools as "one of students and researchers. They will need to come to the Project with, hopefully, an open mind but certainly prepared to attend and contribute to the workshops prepared for them. All should be prepared to try out new techniques and to co- operate with the other Project personnel. In particular the Headmasters must regard the objectives of the Project as worthwhile (and they) must be prepared for a certain amount of disruption and change in their schools."[17]

Closely related to the foregoing was a definite philosophy as to how the computer should best be introduced to students in the project schools. According to the objectives of the project, it was intended that at some point, students should be given an opportunity to work with and experience the technology. However, the innovation was viewed as primarily targeted at the teachers, with the introduction of the technology into formal lessons planned to take place when and if the teacher decided that it was appropriate to do so. With reference to this approach, during the pilot phase, the project proposal states that at the planning stage it had been "decided that only the staff would use the computers (during the the first term of the innovation), since it was realised that they needed a clear head start before using the computers with pupils" (Wray 1985).[18] Giving the teacher the option to decide when to begin using the computers with students would appear to have been based on three assumptions. First, that the teacher would readily adopt the innovation. Second, that the innovation would make available materials (particularly software) which the teachers considered as useful in enhancing coverage and understanding of the content of the Kenya secondary syllabuses. Third, that the teacher is free to engage in far-reaching curriculum innovations, such as integrating computers into formal teaching and learning.

In Parts 4 and 6, the exploration and discovery strategy and the assumptions behind it will be discussed in relation to what actually happened in the course of the implementation.

IMPLEMENTATION APPROACHES

The planning of the project took into account the need for a rationalised implementation strategy. The strategy is best understood through a

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17. Wray, B.F., 1985 (see note 4), p. 18.

18. Wray, B.F., 1985 (see note 4), p. 3.

discussion of each its six main features, namely (1) need for continuous education of the implementation team in the course of Phase II (2) interaction between school staff and other educationists (3) peer interaction within the school staff (4) utilisation of selected forums for teacher education (5) use of written and other forms of communications (6) physical deployment of the project equipment in each school.

On-the-job Education of the Implementation Team

While at the innovator-teacher level the development of the human resource may be readily recognised as an important variable in the implementation of innovations which seek fundamental changes in the teaching-learning process, there may be a temptation to assume that on-the-job education of the innovators is not an essential condition of success. It may be argued that in a particular project the innovator owes his position to the fact that, through prior education and experience, he already possesses the body of knowledge (concepts, ideas, technical expertise, professional practice etc.) which he is seeking to pass on to others. Thus, it may be concluded that all that is needed during the implementation is for the innovator to apply his prior knowledge to the pre-innovation context and thus, synthesise effective learning strategies for the target group. This view of the innovator's role - a static 'know it all' position - is flawed on three counts. First, because we do not (as a scientifically proven fact) know exactly how learning takes place in the human being (Anderson 1983, Shuell 1986, Yarlot 1986), every innovation aimed at changes in the processes of learning ought to be seen as an experiment which seeks to advance the frontier of knowledge in the sphere. As part of his armoury, in the course of the implementation, the innovator should cultivate a position as a learner and researcher who seeks and takes into account the views and findings of others working in the sphere. Second, the innovator's role as a learner and researcher is underscored by the fact that the pre-innovation characteristics of the target group and the overall context in which the innovation is being implemented are complex phenomena, interpretations of which are more often than not subjective judgements rather than scientific proofs. This complexity in interpreting an innovation's environmental map is further compounded where the innovator on one hand and on the other hand the recipients, come from different cultures (Harari 1974, Arndt 1979, McKinley & Young 1979). With reference to the transfer of technology from the North to the South, McKinley & Young (1979) state:

> The transfer of knowhow and skills to recipient countries through technical advisors is not, however, a wholly effective process as there are limitations on the extent to which real transfer of knowhow takes place. Rich country technologies are developed for social and economic conditions quite different from those of poor countries, and advisors such as engineers may inadvertently but unavoidably attempt to transfer knowledge

'inappropriate' to the environment in which they are working.[19]

One of the implications of the above statement is that careful thought should be given to the expatriate innovator's on-the-job education with regard to the socio- economic context in which he is innovating.

A third reason for the innovator's role to be that of a learner and a researcher has to do with the fact that educational ideas and technology are dynamic. The ideas and technologies from which a particular innovation originates do not remain static. What the innovator knows at the planning stage of an innovation is most likely subsequently taken up by a variety of scholars and other professionals, and subjected to fresh thinking, research and development. Thus, if the innovator is to avoid playing the role of conveyor of archaic knowledge, he must have avenues through which he keeps abreast of new thinking, break-throughs and new problems, and thus be able to generate fresh and more relevant challenges for the beneficiaries of his innovation. Because computer technology is changing very rapidly, this mental dexterity is particularly essential among those who are attempting to develop the technology as an educational resource (Baron 1989, Levrat 1989).

A distinguishing feature of CEPAK was the recognition of the importance of continuous on-the-job education of the implementation team. This education was provided at the level of both the PD and his technical assistants.

The PD's on-the-job education, which was coupled with dissemination of the ideas and experiences of the project, took six discernible forms: study of relevant reading materials (particularly the literature regularly acquired for the project library); participation in relevant workshops and conferences (within Kenya, other African countries and overseas); overseas study tours; involvement in university teaching; informal contacts with local professionals; membership of relevant professional bodies. Between 1983 and May 1989, the PD participated in no less than seventeen (twelve of them in the developed North) conferences and workshops in which computers in education was a theme of discussion. In the majority of these gatherings, he presented papers based on the project, thus giving other professionals opportunities to discuss the innovation critically. Prior to the launching of the pilot phase of CEPAK in 1983, the PD undertook a 10-week study tour in England, while in mid-1985 he went on a three-week study tour in the USA. These study tours provided opportunities for the PD to enter into discussion with the staff of institutions (including schools, colleges, universities, education and other public departments, and manufacturers) working on computers in education. During Phase II, the PD acted as an honorary visiting lecturer in the post-graduate diploma course on computer science at the University of Nairobi. At one stage he undertook the supervision of the field work of a student whose dissertation was

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19. McKinley, K. & Young, R. Technology and the Third World: Issues and the Role of Canada. The North-South Institute, p. 61, 1979.

based on computers in education. As part of his informal education, the PD cultivated contacts with local professionals (including university, polytechnic and school staff) involved with computers; particularly important in this regard, were contacts and discussions with teachers working with computers in several non-project schools in Kenya. Before being appointed to head CEPAK, the PD had already become a fellow of the British Institute of Analysts & Programmers. While working in CEPAK he became a member of the Kenya Computer Institute, a body which organises monthly meetings to discuss various professional issues.

In the first six months of Phase II, the project had only one technical assistant (TA). The number of TAs was raised to three in January 1987. In all cases, the PD sought to recruit TAs who had had some exposure to computers. Three of those recruited were secondary school leavers who had been exposed to IT at a Nairobi school which had acquired computers. The latest of the recruits - taken on in early 1988 - had graduated from the Kenya Polytechnic where he had acquired an ordinary diploma in computer science. Prior exposure to computers facilitated the on-the-job training of the TAs: when interviewed, two of the TAs recruited after leaving secondary school confirmed observations that prior exposure had helped them overcome anxiety over the technology and had given them the technical knowledge necessary for training within the project.

The on-the-job training of the TAs was characterised by two main features. First, the PD gave functional training in which the TAs were encouraged and guided to undertake technical tasks - within the office or in schools - related to the on-going work of the project. The TAs - through reference to manuals, discussion among themselves and posing questions to the PD - were required to undertake tasks such as word-processing of reports on school visits and simple administrative documents to schools, establishing and maintaining equipment databases, diagnosing the causes of and rectifying the malfunctioning of hardware and software, assisting school staff with technical operations, and carrying out simple project-related programming tasks. Second, in recognition of the commonly accepted need for formal certification, the project funded a relevant correspondence course for two of the TAs who had joined the project directly from school. The two were encouraged to use reading materials in the library to supplement what was provided by the correspondence college to prepare for an examination - scheduled for April 1990 - leading to the award of a higher diploma in computer studies.

Characteristics of the Teacher Development Effort

The exchange of ideas and points of view at several forums was seen as an important approach to teacher development. Discussion between the PD and the staff in the project schools was intended to play a central role in the adoption and adaptation of the educational ideas advocated in the innovation. Further, discussion and interaction was planned to include exchanges which did not necessarily include or require the physical presence of the PD. In Phase II, the staff of the pilot school, external consultants, school media co-ordinators, and collegial interaction

between staff in the same school and in different project schools were visualised as playing major roles in teacher development.

Role Played by Staff of the Pilot School

The staff of the pilot school was expected to play the role of workshop tutors, a role which required that they both discuss their experiences with the technology and introduce certain project ideas to participants from the other schools. In pursuit of these expectations, about a fifth of the teachers at the pilot school were observed leading sessions in the start-up workshops (held during the third quarter of 1986) for staff in the five new Phase II schools. Thereafter, the staff of the pilot school continued to constitute the majority of tutors in project workshops: it was noted that, between December 1986 and December 1988, out of 45 teachers who acted as tutors in project workshops, 20 (44%) were members of staff at the pilot school.[20]

Contribution of External Consultants in Workshops

The PD sought to widen the realm of professional interaction by inviting a number of Kenya-based educationists to participate in project workshops. Up to December 1988 eleven consultants were observed taking part in various workshops. The consultants included a university lecturer in chemistry, an educational researcher working in the World Bank regional office, two secondary school heads, a primary school head, a former primary school English teacher, two curriculum developers, a graduate student at the University of Nairobi, and two members of the project research team.

The criterion used in selecting consultants was knowledge and experience of educational theories and processes, rather than expertise in computers or their specific applications to education. In the majority of cases, the consultants had little or no knowledge of the operations of the computer. This approach to selecting consultants to act as workshop tutors was in recognition of an important dictum that thinking about computers in education ought not to mean thinking about computers, it should mean thinking about education (Ellis 1974). Thus, in projects which aim at developing teachers to integrate computers into the curriculum, there should be due emphasis on the interrelationships between the technology per se, educational theory, teacher pedagogical perceptions and practice, and the wider socio-economic implications of formal education (Commonwealth Secretariat 1987, Stone & Bartlett 1987). There is evidence that in a number of CEPAK workshops the consultants attempted to help school staff visualise the computer innovation in the wider context of: (a) linkages between formal education and issues in the

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20. As some of the teachers from the new Phase II schools acquired experience of the innovation, they were invited to act as leaders in workshops. Between May 1987 and December 1988, 25 teachers from the new schools (Q -9; S - 7; R - 6; T - 3; P - 0) were observed leading workshop sessions.

development of Kenya society (b) managerial and pedagogical factors necessary for improving the quality of learning. The following four examples are illustrative.

In September 1987, a consultant with a research background on the macro-issues of the linkages between school education and society was invited to lead discussion in a workshop for the heads and deputy heads of the project schools. Having outlined the twenty-first century economic, social and environmental ramifications of Kenya's demographic trends, the consultant observed that education could prepare the youth currently in school to meet the ensuing challenges, provided education placed emphasis on three key areas:

> The first is to instill a spirit of innovativeness, entrepreneurship and resourcefulness, the psychological attributes which will help these people create plenty out of scarcity. The second is a sociological orientation that promotes harmonious co-existence of man and nature, while the third is a strong technological base.[21]

Linking the computer innovation to the foregoing wider preparation, the consultant concluded:

> The introduction of computers in schools fits into the category of efforts that can enrich the technological environment, stimulate thinking and resourcefulness.[22]

In the same workshop another consultant, an experienced and progressive secondary school head, had been invited to lead discussion on the role of school management in improving the quality of learning, an aspect considered essential in the development of the computer innovation. After identifying commitment, competence, confidence and consistency as essential qualities for headship, the consultant focused on the centrality of the head's leadership in the learning process as follows:

> Most of us head teachers lack initiative and the right perception of what needs to be done in our institutions. We are most times content with routine things in our schools and are not ready to explore other areas of how best we can make learning more effective and our schools a better environment for teaching and learning. We do not address curselves fully to the task of creating a school (that will be appreciated by) all (the) people concerned. If heads were committed to

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21. Kagia, R.W. What are the needs of the young people who will be the leaders in 2010? How does our present education system attempt to deal with these and what changes are required for greater effectiveness? How do you suggest that these changes could be achieved? Paper presented at a CEPAK workshop for heads and deputy heads, p. 1, September 1987.

22. Wray, B.F., 1985 (see note 4), p. 5.

> achieving the best through positive discipline, hard work and proper time utilisation by both staff and students, then I certainly believe a lot of the problems that plague our schools today would be minimised.[23]

A former teacher of English was invited to work with English teachers in a weekend workshop held in May 1987. Responding to the frequent complaint that there was little in the way of software which was specifically geared to the teaching of language, the consultant illustrated that software in other disciplines could be adapted for use in language lessons. Using two programmes, **Voyage of the Mimi** (biology) and **Where on Earth is Carmen San Diego?** (geography) she planned and conducted two sessions in which the participants discussed and practised use of the programs in the teaching and learning of language skills such as comprehension, sequence in organising ideas, note-making and essay writing. In a third session, she illustrated further the need for language teachers to improvise. By introducing non-computer materials - newspaper clippings, artifacts and photocopied works of art - she demonstrated that teachers could use the immediate environment to teach language in an interesting and effective way. In all three sessions the consultant demonstrated and emphasized the importance of thorough preparation by the teacher, active student participation and the need for the teacher to play a guiding and motivating role during a lesson.

In September 1987, the headmistress of a primary school who also taught social studies was invited to lead a session in a workshop for humanities' teachers. Basing her remarks on the topic 'Approaches to Teaching', she illustrated that using both a variety of approaches and resources in the environment the teacher could make learning in social studies motivating and meaningful. The relevant part of the session proceeded as follows.

The consultant began by making the remark that we all need food but that we get it cooked and presented in different ways. She reckoned that education should be similar:

> We all need it and it should be presented in different ways.

She pointed out that traditional education was by example and doing, while the current approach is that the teacher talks and the pupils listen.

> This is particularly so in history. Both pupils and teachers seem to be bored by history with its sequence of facts, facts, facts! In the teaching of history it is not enough to read the book and give a few notes.

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23. Maneno, S.S. Current Problems in Organising a School. Paper presented at a CEPAK workshop for heads and deputy heads, p. 5, September 1987.

She went on to describe how she approaches the teaching of history:

> What I do in class - it's a bit unusual, but I like it and the students like it! Students today like pop music. I occasionally use pop music in history lessons.

To illustrate her approach, she sang two songs, one on Shaka Zulu and the other (to the tune of **The Rivers of Babylon**) on the Maji Maji Rebellion.[24] Both songs contained all the relevant facts but presented in an imaginative way. She continued:

> Most of you will feel, 'Well now, I can't sing', but you have to use your own special talents to make note- giving interesting. We think that secondary school students are adults and don't like to play at things. But look at how much time they spend working at plays for the drama festival or songs for the music festival.

Turning to the importance of wide reading and story telling by the history teacher, she said:

> I always try to read as much as I can about the topic I am going to teach.

She gave as examples two stories she had read about King Mshoeshoe of Lesotho and the explorer, Mungo Park:

> How did King Mshoeshoe get that name? Shoeshoe is the sound made when shaving and it was said that he shaved away everybody else's cattle, 'shoeshoe, shoeshoe!' A small story like that gives the man personality with information not available in the textbook. Take Mungo Park in West Africa. People wondered why he was white, and the story grew that he became white by always being bathed in milk when he was a baby.

On actively involving students in learning activities and making use of resources in the environment, she advised the participants a follows:

> Involve the pupils themselves in their learning. Organise them in groups. Do you use groups?...Have discussions. Get pupils involved in projects and research. You must know what you want them to do. Choose good group leaders. Check periodically what each group is doing. Pupils collect much more in group research than they get from you. Get them to make a book of what they have found out... Get outside speakers to talk to them about different topics. The parents of the pupils in the school know a lot about many different topics. Use the resources you have... Use embassies, information centres, the National Christian Council of Kenya, British Council... It's not only

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24. Both topics are part of the primary school history syllabus.

teachers who provide learning...

> Use models in geography. Do you use models? Use papier mache, clay, etc. What they learn about physical features is much better implanted in their minds when they make the models themselves... Think about the effect of environmental factors on culture and history. Use games. Try **Historical Monopoly** and other games with historical or geographical themes to help children to internalise what they learn.

This was a stimulating and refreshing session which presented a fresh and innovative approach to teaching social studies. The speaker was obviously enthusiastic about her subject and was clearly talking about things she had done herself, thus through personal example, nudging the participants to put their current teaching approaches under the micro-scope. In relation to the computer innovation, the session aimed at helping the participants to visualise the new technology as another resource in the environment which could, with imaginative application, be used to make teaching and learning interesting and meaningful.

School Media Co-ordinators

In planning CEPAK, it was recognised that at the school level a member of staff would have to take responsibility for the day to day running of the project. The Phase II project proposal stated:

> As the Project proceeds certain teachers in each of the schools will be identified for special roles to cover certain aspects which will need building within each staff...Included in these roles is that of "Resource Co-ordinator", a person in each school with the express responsibility for the computers' use and development of that use.[25]

Following practice in the pilot phase, in Phase II the resource co-ordinator was given the title, School Media Co- ordinator (SMC). In a detailed appendix to the project proposal, the responsibilities of the SMC were specified as follows: (1) undertaking simple preventive maintenance of the equipment; (2) diagnosing causes of malfunctioning of the equipment; (3) administering the resource centre (including sched-uling use of the equipment, and controlling formal and informal use of the technology by students); (4) assisting teachers with technical operations; (5) through in-house workshops and guidance to individuals, assisting other teachers in developing use of the technology as an educational resource; (6) liaising with the school head and senior staff with regard to training needs of the staff and the management of the project; (7) on behalf of the school head, liaising with the project office in relation to repair and maintenance, acquisition of software and educational materials, and staff education activities.

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25. Wray, B.F., 1985 (see note 4), p. 18.

By the beginning of Phase II, a SMC had already been appointed at the pilot school. In the other five schools SMCs were appointed soon after Phase II had got off the ground.

Given the heavy responsibilities to be undertaken by SMCs, it was recognised that the project would have to give special training to this cadre of staff. The project proposal specified that in the course of three years, the PD would devote 23 working days to special workshops for SMCs. In the course of the implementation it was observed that, in addition to attending most other project workshops, the SMCs participated in three workshops specially organised for them (Nairobi: December 1986 - 10 days; Mombasa: August 1987 - 10 days; Nairobi: August 1988 - 3 days).

In principle the perception that the new position of SMC needed to emerge appeared to be a sound idea. However, the creation, development and harnessing of the potential of the position was dependent on the successful manipulation of several variables. The successfull evolution of the position of SMC was dependent on appropriate action in four areas as follows:

(1) That the emergence of the SMC would occur in an orderly and logical manner: after the launching of the project, the heads of schools would bide their time, carefully observing the response of their staff to the innovation before appointing SMCs. The project proposal stated that SMCs should be appointed one year after the launching of Phase II, "with each school doing so as it is ready" (Wray 1985).[26]

(2) That the training given to the SMCs would sufficiently equip them to adequately carry out the specified responsibilities. This assumption related not only to the sufficiency of the time given to and the relevance of the content of the SMCs' workshops, but also to the suitability of the discovery strategy employed in the implementation.

(3) That other teachers in the staff would recognise the position of the SMC and be willing to receive guidance on technical and professional issues from a peer. Implicit in this assumption were two beliefs that: (a) peer interaction over professional issues is common among members of staff of a school (b) merit based on professionalism is the basis of hierarchy in a school staff: heads appoint to professional positions those members of staff who merit and are seen by peers to be so.

(4) That school heads would wholly understand and embrace the schedule of the SMCs' responsibilities detailed in the project proposal. In particular, this assumption implied that the head would be willing and have the knowledge to weigh the time implications of the SMCs' responsibilities and to decide whether or not the new position

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26. Wray, B.F., 1985 (see note 4), p. 18.

should be filled by one or more teachers.

The significance of the foregoing aspects of the development of SMCs will be discussed in later sections. At this stage, two observations - which could be generalised for most innovations - can be made. First, there is need to carefully project the planning of an innovation into the realities of implementation. In the case of CEPAK, the proposed gradualism in the emergence of the SMC proved to be impractical. Given that as soon as the equipment had been installed in each school the project became a reality, the head (unless he or she personally took on the job, and none did!) had to promptly delegate the innovation to one or more of his or her staff. As equally important, the first workshop for would-be SMCs was planned to take place at the end of the first term of Phase II. Each head had to appoint at least one teacher to attend the workshop, thus de facto appointing an SMC. Perhaps largely on these two counts, the heads of the five new Phase II schools felt constrained to appoint SMCs during the first term of the project. However, this reality could not but contradict the fact that, at that early stage, the positions were filled on the basis of meagre evidence of mastery of the technology or the pedagogical ideas of the innovation.

A second observation has to do with the dichotomy that can arise between, on one hand the ideas of the innovator and on the other, the interpretation of those ideas by the beneficiaries of an innovation. Such a dichotomy, which can orientate the implementation towards approaches not planned by the innovator and thus derail some of the innovation's ideals, is aggravated if the innovator does not give detailed guidance and advice to grass-root actors. To an extent, the foregoing was observable in relation to the emergence of SMCs. The PD, perhaps rightly reasoning that professional appointments in the schools fell outside his purview, was content to leave the identification and appointment of SMCs to the heads. However, this line of reasoning had flaws: it assumed that, without systematic advice and guidance from the PD, the heads clearly understood what would be entailed in the new job and that they were able to establish rational criteria on which to base the appointments. Issues such as the type of person needed, the number of SMCs per school and the division of responsibilities if more than one SMC per school was appointed, needed to be systematically discussed and agreed upon with the heads earlier on in Phase II rather than later.

Because of the large measure of autonomy given to the heads with regard to the appointment of SMCs, a mixed situation developed in the five new Phase II schools. In school P two SMCs were appointed, but in practice most of the work was done by one of the two, although the other continued to attend workshops and seminars intended for SMCs. In school Q three teachers with responsibility for the resource centre (RC) were appointed, but one of the three (who had greater authority in the school management hierarchy and who attended all SMC workshops and seminars) never did more than act as custodian to the RC key and some of the software in the school. In school R one teacher was entrusted with the main responsibility for the RC, although he was assisted by two other teachers. In school S three teachers were appointed, but after about half a year one

had so exerted her authority and control over the RC that the other two quietly gave way. In school T three teachers were initially appointed, but in early 1987 one of the three was given a reduced teaching load so that she could become the main SMC.

The research evidence leans towards the finding that throughout Phase II, the heads of the new schools visualised the role of the SMC as something less than conceptualised in the project proposal. After one term the head at school T abandoned the idea of a reduced teaching load for one of the SMCs; in the other four schools, no attempt was made to re- allocate pre-innovation duties so that SMCs could have the time necessary for development of the new role. SMCs continued to be visualised largely as custodians of the equipment and channels of communications with the project office in relation to technical issues. One of the heads consistently expressed the opinion that the role of SMC as conceptualised in the proposal was impractical in a school setting. In an interview in October 1986, while expressing gratitude that his school had been included in the project the head stated:

> I have not been able to give much attention to the project in the current term because the school's priority is to concentrate on preparations for the O and A level exams due to start in the third week of October...It is not easy for teachers in this school to find time within the official day to work on the new technology. Most of the teachers here have teaching loads of between 25 and 30 periods per week... Worldwide there is a tendency for teachers not to have the inclination to adapt to new approaches in their work. I fear that most of the teachers in this school will not on their own take to working with the microcomputers.

The head then proceeded to suggest that what the school needed was to have on the staff a person who was already qualified in the educational use of computers and who "is able to give the teachers the necessary kick." In another interview in July 1987, the head clearly stated that he did not consider the SMC's role as per the project proposal appropriate for his school:

> I have on my staff some good and knowledgeable teachers who could very successfully take on the role of media co-ordinator. However the thing is, do I want to lose a good teacher to this new position? How do I replace him? It is also important to bear in mind that, with the sort of salary available in teaching, you will lose your media co-ordinator to business or industry once he receives training and experience in computers.

This particular head could very well have been expressing the unspoken feelings of the other heads.

Workshops and Seminars for School Staff

At the beginning of Phase II, all the staff in each of the five new

schools were invited to attend a 10-day (about 70 working hours) start-up workshop. For schools Q, R, S and T the workshops took place during the school vacation in August 1986, while for school P the workshop took the form of evening and weekend sessions during term time in September and October 1986. The majority of teachers from the schools attended most of the sessions in the start-up workshops, although (as indicated by about 50% who filled an evaluation questionnaire on the last day) there was a tendency for drop-outs to increase as the workshops progressed. In addition to giving participants a background to the development of the technology, the sessions were devoted to hands-on experience and some discussion of the educational applications of computers.

In addition to the start-up workshops, between December 1986 and December 1988 the staff in the six schools received a total of 1154 man/days (approximately 5770 man/hours) of training in 44 workshops organised by the project. The man/hours of training were distributed over the three calendar years as follows: 1986 - 385; 1987 - 3375; 1988 - 2010. Table 2.14 shows the number of staff who attended the workshops. Table 2.15 shows the maximum number of workshops attended by the 149 members of staff.

Table 2.14. Attendance at CEPAK Workshops, 1986 - 1988.

School	Number of Staff
P	21 (14.1%)
Q	20 (13.4%)
R	26 (17.4%)
S	23 (15.4%)
T	15 (10.1%)
U	44 (29.5%)
Total	149 (99.9%)

Table 2.15. Maximum Number of Workshops Attended by Staff.

n = 149

Number of Workshops	Number of Staff
1	64 (43.0%)
2	44 (29.5%)
3	14 (17.4%)
4	10 (6.7%)
5	6 (4.0%)
6	6 (4.0%)
>7	5 (3.4%)

The data in tables 2.14 and 2.15 reveal two important trends. First, less than 50% of the teacher establishment (see Table 1.02) in schools P, Q, R, S and T attended at least one workshop organised by the project. Second, of the 149 staff exposed to project workshops 72.5% attended only one or two workshops. These findings indicate that the successful implementation of the innovation, both in terms of the number of staff exposed and the quality of exposure, was to a considerable extent dependent on other channels of in-service education - such as the PD's visits to schools, written communications, workshops and seminars organised by the schools, and peer interaction within staff.

The man/hours of training were distributed to four categories of workshops as follows: general - 38%; school management - 25%; subject-specific - 22%; software and courseware development - 15%. In the general workshops training was provided in the use of a variety of computer applications, such as wordprocessing, spreadsheet, database, graphics programs, simple programming in LOGO and PILOT, and use of computer-assisted learning (CAL) software. Participants were also given rudimentary ideas on the technical operations of a microcomputer including booting, data in-put and out-put, management of data files, and preventive maintenance of the hardware and software. Subject-specific workshops were organised for teachers of a specific subject (e.g. mathematics) or a range of related subjects (e.g. sciences, languages, social sciences and business education). During subject-specific workshops participants were introduced to various CAL programs. The teachers were given opportunities to discuss the relevance of the software content to their disciplines and to explore teaching-learning strategies which could be applied in lessons. School management workshops were variously attended by heads, deputy heads, SMCs, senior teachers in charge of students' academic progress, and non-teaching accounts staff. The workshops covered management techniques and the role the microcomputer could play in improving efficiency in school management, particularly in the spheres of the head's guidance of the learning process, administration and financial accounting. Workshops specifically organised for SMCs attempted to cover the full spectrum of the responsibilities spelled out in the project proposal. Courseware development workshops were organised to provide SMCs and selected teachers with expertise in the production of CAL software and other materials (e.g. charts and overhead projector transparencies) for use in the classroom.

On their own, the schools were expected to mount in-house workshops for their staff. However, it was noted that only two of the schools, R and U, organised formal workshops in which the more experienced staff led the rest in attempts to develop some aspects of the innovation.

Interaction Between the Project Office and Schools

In planning CEPAK it was recognised that, in addition to workshops, other forms of interaction between the project office and the schools were important in developing the innovation. It was planned that "the six schools and the project office will...be linked by an electronic network using a modem and the telephone system...to draw all the people involved

despite the distances."[27] Although modems were purchased the network was not established. Throughout Phase II communications between the office and the schools was maintained through telephone, written correspondence, a project newsletter, and visits by school staff to the office and by the implementation team to the schools.

With regard to written communications, up to December 1988 the PD had prepared 34 handouts for schools in connection with technical and operating aspects (19), sample activities in the use of computer programs (9), project library (3), computer programming (2), and organisation of the computer room (1). The CEPAK newsletter was supposed to be produced every quarter, however only five issues (December 1986, March 1987, June 1987, December 1987 and July 1988) - with a mean length of 6 pages on A5 paper - were produced. Although the newsletter took the form of general information on project activities, some of the articles contained material which complemented workshop sessions aimed at the development of new teacher perceptions. For instance, reporting on an international conference which the PD had attended, the fifth issue stated:

> It would appear that many Universities now recognise the need for more learner control but that, at the classroom level, there is difficulty in implementing this methodology since we have not yet worked out a proper strategy for placing the teacher in the role of facilitator and consultant, rather than that of director.[28]

Visits to the schools by the PD and the technical assistants were important in that they provided an opportunity for the implementation team to support the innovation in situ. A technical assistant visited each of the schools once every month to carry out certain aspects of preventive maintenance of the equipment and to assist teachers with technical operations. Further visits were organised whenever schools made requests. The PD visited each of the schools on a monthly basis (2 days per month during the first year of Phase II and thereafter 1 day per month). During these visits, he worked with staff on technical aspects, discussed ideas and management of the innovation with the head and senior teachers, and on request from individuals, entered into professional discussion with subject teachers.

Physical Deployment of Project Equipment in Schools

As part of its contribution to the project, each school was required to make available a secure room to house project equipment and to be used by teachers and students as a resource centre (RC). With the exception of School T which was given some financial assistance by the project, the schools undertook expenditure on burglar-proofing the RCs, installing

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27. Wray, B.F., 1985 (see note 4), p. 12.

28. Wray, B.F. UK conferences & Meetings. CEPAK Newsletter Issue No. 5, p. 6, 1988.

appropriate electrical wiring and providing furniture. Further, all the schools consented to meeting project-related recurrent costs of electricity, postage, telephone, cleaning materials and stationery (in particular, stencils and duplicating paper).

The decision to centralise the computers in a special room, to an extent based on experience during the pilot phase, was dictated by consideration of security and safety of the equipment, and the reasoning that if the small numbers of computers were to effectively be used in lessons with whole classes, it was better to deploy them in one place. However, this approach had some disadvantages. First, its success was dependent on the availability of a room large enough to accommodate a class of 40+. Second, the arrangement ran the danger of introducing both psychological and practical barriers to the development of the innovation. Many teachers, not used to teaching in special rooms with sophisticated equipment, might be reluctant to take their classes to the RC. Equally important, the idea of a special room to house the technology made the issue of access potentially troublesome, particularly in relation to possible restrictions associated with control of the room by the SMC and the likelihood that more than one teacher might wish to have lessons in the RC at the same time.

School U undertook the most advanced development of the RC. A large RC was created by dismantling the wall between two adjacent classrooms. Special tables which facilitated grouping of students during lessons were purchased. Schools P, Q and S converted ordinary classrooms into RCs but, while the rooms could be used by a full class, the chairs and desks in the rooms were often observed to be inadequate for classes of 40+. At School T, the equipment was originally housed in a room whose area was about half of a classroom. In early 1987 the school converted a classroom into a temporary RC and purchased a trolley for transporting the equipment between the two rooms. However, because the school needed an additional classroom, at the beginning of 1988, the use of the temporary RC was curtailed. In school R the RC had a smaller area than that of the permanent RC at school T. The head of school R kept promising that on completion of new classrooms - observed to be under construction during most of Phase II - a classroom size RC would be made available.

The inputs, discussed in Part 2, into the project were expected to play a major role in the realisation of the innovation's objectives. In-school staff and student use of the technology, and responses to the innovation are the subjects of discussion in Part 3.

PART 3

OUTCOMES OF THE INNOVATION

APPROACHES IN EVALUATING THE IMPACT OF THE INNOVATION

In dealing with data on investments in education, economists make a distinction between cost-effectiveness and cost- benefit analysis. While the same data may be used on the cost side, different approaches are used in relation to effectiveness as opposed to benefits. Equating cost-effectiveness of an education system with its "internal efficiency", Coombs & Hallak (1987) state

> Thus defined, an educational system's internal efficiency may be judged in terms of its cost- effectiveness, measured in this context by the system's immediate outputs as distinct from its ultimate benefits. Any judgement of cost-effectiveness requires both an economic assessment to measure the cost of inputs, and a pedagogical assessment of the learning achieved.[1]

The costs of CEPAK are discussed in Parts 4 and 5. In Part 3, the discussion dwells on the outcomes of the innovation. In particular, the type and nature of the beneficial outcomes of the innovation are highlighted.

With regard to benefits accruing from investments into an education system, Coombs & Hallak (1987) maintain that

> The ultimate purpose of any educational system is not simply to produce immediate educational outputs...but to generate longer-term benefits accruing from the actual use of those immediate learning results...The benefits take many forms, both economic and non- economic, individual and social. Individuals, for example may benefit by getting better jobs and higher lifetime earnings, by having more satisfying family lives, by adding richer cultural and civic dimensions to their existence, and by a greater sense of participation in the surrounding world. The society at large may benefit from higher production and better living standards, from an enlarged supply of effective leadership at every level, and from enrichment of its culture through the release of greater creativity in more people.[2]

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1. Coombs, P.H. & Hallak, J. Cost Analysis in Education - A Tool for Policy and Planning. Baltimore: Johns Hopkins University Press Baltimore, pp. 9-10, 1987.

2. Ibid., p. 8.

Although desirable, the study into CEPAK - on account of its short time frame and limited resources - did not attempt to analyse costs of the computer innovation in relation to the long-term benefits expected to accrue to the students, school staff, schools and society at large. The study concentrated on documenting inputs into the innovation and attempting to relate them to outcomes in the immediate learning situation.

A commonly used approach in assessing the cost-effectiveness of educational innovations is the attempt to relate inputs to gains in academic achievement. Academic achievement as the independent variable could take the form of performance in public examinations or in specially constructed pre- and post-innovation tests. In the CEPAK study, academic achievement was not considered a suitable measure of effectiveness. Three reasons were advanced in defence of this decision. First, the literature on the introduction of computers in schools reports mixed findings on the effect of computerisation on test scores (Bangert, Kulick & Kulick 1983; Becker 1984; Mevarech & Rich 1985; Roblyer 1985). Second, the project's central ideal - the development of learning as a learner-centred process geared to the nurture of life-long problem-solving skills - is most likely not suited to measurement through traditional paper and pencil tests. Third, the level of investment in equipment in CEPAK appeared to be such that not all teachers and students could be exposed to the technology for sufficiently long periods, thus making it reasonable to expect the innovation to result in significant achievement gains.

SCHOOL STAFF USE OF THE TECHNOLOGY AND EFFECTS

Access to the Technology

It stands to reason that teachers' physical access to the technology was bound to be a crucial factor in the development of the computer innovation. Access to the RC (in which the hardware, software, manuals and other documentation were accommodated), was visualised as an important indicator. In the 1988 survey of teachers, an item in the questionnaire required respondents to indicate how difficult or easy it was for them to have access to the RC. Out of 101 teachers who responded to the item, 80 (79%) felt that it was easy for them to have access to the RC. However, although the RCs were easily accessible to the majority in the teacher sample, it should be noted that the sample (representing 41% of the total teacher establishment) most likely consisted of those teachers who had taken interest in the innovation. It is thus conceivable that if the majority of the staff had taken to working with the computers, there could have been serious problems in gaining access to the RCs.

A teacher could only conduct a computer-assisted lesson if in a particular subject the relevant period coincided with a time when computers were available. Thus, access to the technology was also gauged on the basis of data on the number of computer-assisted lessons conducted by teachers. In the pilot school 23 teachers (92% of the sample and 71% of

the total establishment) responded that they had used a computer in a lesson on at least one occasion during Phase II. The corresponding figures for the five new Phase II schools were 31 teachers constituting 37% of the sample and 13% of the total establishment. A clearer picture of the use of computers in formal lessons is shown by analysis of data on the use of the computers during a definite period in Phase II. With reference to the third term of 1988, the teachers were asked to indicate the number of times they had taken a class to the RC. Table 3.01 shows the means and standard deviations of the teachers' responses.

School U stands out as the one institution where the use of computers in formal lessons was most developed. Observations at the school revealed that, with a fully developed IT course and a substantial core of subject teacher-users of the computers, the RC was fully occupied during most of the teaching day. However, in school U the high standard deviation relative to the mean indicates large variations among the teachers in the use of the technology in formal classes.

Familiarity with Technical Operations of Computers

Familiarity with the technical operations of the computer is a necessary condition for use of the technology as a teaching and learning tool. In the 1988 survey teachers were asked to indicate whether or not they had personally carried out five basic tasks in operating computers. Analysis of the responses is shown in Tables 3.02.

Table 3.01. Mean and Scatter of Number Of Times Teachers Used Computers in Lessons During Term 3 of 1988.

	P	Q	R	S	T	U	Average
Mean	1.09	1.08	0.65	1.42	0.31	7.13	2.30
SD	2.43	1.00	1.43	2.68	0.75	14.38	7.40

Table 3.02. Teachers' Familiarity with Basic Tasks in Operating Computers.

	Percentages of Respondents						
	P n=22	Q n=13	R n=23	S n=12	T n=15	AII n=85	U n=25
Started a computer	68	85	61	83	13	61	84
Loaded a disk	55	77	57	83	20	57	88
Made a new file	64	54	61	67	47	59	68
Saved a file	64	46	57	67	27	53	80
Printed a file	55	39	52	58	13	45	64
Done none of these	18	8	35	0	47	24	4

	Percentages of Total Establishment						
	P n=49	Q n=30	R n=50	S n=38	T n=42	AII n=209	U n=35
Started a computer	31	37	28	26	5	25	60
Loaded a disk	25	33	26	26	7	23	63
Made a new file	29	23	28	21	17	24	49
Saved a file	29	20	26	21	10	22	57
Printed a file	25	17	24	18	5	18	46

Note: AII = Average for new Phase II schools.

The data in Table 3.02 show that a fair number of teachers had developed some expertise in operating the computer. In the new Phase II schools between about a fifth to a quarter of all teachers claimed to have acquired familiarity with the five basic tasks. Significantly higher proportions were reported in the pilot school. Given the newness of the technology and the small number of computers, the proportions of teachers who had some competence in the five operations must be regarded as an important indication that the innovation had taken root in all six schools. However, the data in Table 3.02 also show that the development of technical competence was taking place at different rates across the five operations. As compared to switching on the computer and booting a disk familiarity with creating, saving and printing new computer files was reported by smaller proportions. This finding is significant in that expertise in developing new files is an essential condition for using the computer (e.g. in wordprocessing) to create and produce printed copies of teaching or learning materials. In all six schools, using the computer to print a file was reported by the smallest proportions of teachers. These proportions should be regarded as an indication of the extent to which teachers used the computer to produce handouts and tests for students.

Familiarity with Computer Software

Whether in education or in other spheres of everyday life, the availability and use of software is a necessary condition for the meaningful application of computers to specific tasks. The teachers were asked to indicate whether they had used different types of software provided by the project. Analysis of the responses is shown in Table 3.03.

The data in Table 3.03 corroborate observations that, in all six institutions, a number of teachers were using the technical expertise - discussed in the previous section - to apply specific software to certain tasks. Scrutiny of the data reveals that, as was the case with regard to familiarity with technical operations, the application of software to tasks varied a great deal between schools. Use of most of the programs was reported by the highest proportions of teachers in school U. At the other extreme, use of the software was least developed in schools R and T. The data also show variations in the use of different programmes as

Table 3.03. Teachers' Use of Different Types of Software.

	Percentages of Respondents						
	P n=22	Q n=13	R n=23	S n=12	T n=15	AII n=85	U n=25
Wordprocessor	59	69	65	83	40	63	60
Spreadsheet	46	38	35	25	13	33	36
Database	36	8	48	33	7	29	44
CAL program	32	62	30	75	7	38	68
Graphics	23	15	17	25	7	18	32
None of these	32	8	35	0	53	28	16

	Percentages of Total Establishment						
	P n=49	Q n=30	R n=50	S n=38	T n=42	AII n=209	U n=35
Wordprocessor	27	30	30	26	14	25	42
Spreadsheet	20	17	16	8	5	13	26
Database	16	3	22	11	2	12	31
CAL program	14	27	14	24	2	15	49
Graphics	10	7	8	8	2	7	23

Notes: (1) AII = Average for new Phase II schools.
(2) The wordprocessor, spreadsheet and database referred to are component parts of the program **Appleworks**.

follows. First, overall among the teachers the wordprocessor (WP) was the most commonly used program, although in school U it came second to CAL programs. Scrutiny of teachers' computer disks indicated that most of the new files made were in WP. Of 788 teachers' computer files examined in mid-1988, 72.1% were in WP, 17.4% in the spreadsheet and 10.5% in database. Second, as compared to 15% in the new Phase II schools, 49% of teachers in the pilot school had used CAL programs. Observations at school U indicated that by the end of Phase II, computer-assisted lessons had become a regular feature. Third, in all schools use of graphics software was reported by the smallest proportions of teachers.

Teacher Use of General Applications Software

The teachers were asked to indicate whether they had used the wordprocessor, the database, the spreadsheet and graphics programs in undertaking specified official tasks. In Tables 3.04 to 3.07, the teachers who registered positive responses are shown as proportions of the total teacher establishment. Note that in the four tables AII refers to the average for the five new Phase II schools.

Table 3.04. Teachers' Use of Wordprocessor to Produce Specified Documents and Teach Lessons.

	%s of Establishment						
Task	P	Q	R	S	T	AII	U
Exam papers	22	23	18	24	10	19	40
Students' handouts	14	10	18	16	12	14	20
Teaching notes	6	10	14	8	5	9	8
Memos & circulars	4	3	10	8	2	6	6
Schemes of work	10	0	2	3	0	3	6
Teach lessons	0	3	10	3	2	4	23
N	49	30	50	38	42	209	35

Table 3.05. Teachers' Use of Database to Produce Specified Documents and Teach Lessons.

	%s of Establishment						
Task	P	Q	R	S	T	AII	U
Mark lists	12	7	20	11	2	11	23
Class lists	6	3	16	13	2	9	17
House lists	6	0	4	8	0	4	6
Equipment lists	2	0	4	0	0	1	3
Teach lessons	0	0	6	3	2	2	0
N	49	30	50	38	42	209	35

Table 3.06. Teachers' Use of Spreadsheet for Calculations in Specified Areas and to Prepare Schemes of Work.

	%s of Establishment						
Task	P	Q	R	S	T	AII	U
Exam data analysis	16	3	10	5	2	8	9
Mathematics lessons	10	0	10	0	2	5	11
Physics lessons	4	0	4	0	0	2	3
Produce schemes of work	14	0	4	3	0	5	26
N	49	30	50	38	42	209	35

Table 3.07. Teachers' Use of Graphics Programs to Make Teaching-Learning Materials.

Product	%s of Establishment						
	P	Q	R	S	T	AII	U
Diagrams	4	7	4	5	2	4	20
Bar graphs	4	0	10	11	0	5	6
Pie charts	2	0	8	5	0	3	6
Geographical maps	0	0	4	0	0	1	6
N	49	30	50	38	42	209	35

Four observations can be made on the data in Tables 3.04 to 3.07. First, although in all six schools the four types of application software had been used by less than 50% of the establishment, there was a core of teachers who had begun to relate the new technology to the normal work of the teacher. This core of teacher users was an indication of the extent of the innovation's success and was a good base for further development. Second, as noted in the previous section, the wordprocessor had been used by higher proportions of teachers than was the case for any of the other three types of software. Third, there were considerable variations between schools: for instance, in all four types of software the core of users was biggest in school U and smallest in school T. Fourth, in all schools the majority of users applied the programs to the production of teaching- learning materials (such as examination papers, handouts, and schemes of work), analysis of examination data, and management tasks. In contrast, relatively small proportions of users indicated that they had used the software in direct classroom teaching. This finding was corroborated by ethnographic data, as well as statistical data on the teachers' perceptions of spheres in which the innovation had achieved most success.

In-school interviews and observations revealed that, in contrast to integrating the technology into formal classroom teaching, school staff found it easier to understand and develop use of the computer in the production of teaching and learning materials, and the management of the school. In the 1988 survey a number of questions were aimed at quantifying the teachers perceptions of CEPAK's success in relation to these aspects. Tables 3.08 and 3.09 show analyses of responses of teachers who felt that 'Most Success' had been achieved in nine specified areas.

As per Table 3.08 school U stands out as the one institution in which the majority of staff were convinced that 'Most success' had been achieved in the nine spheres. However, the fact that in all the other schools a core of teachers had similar convictions is an indication of the innovation's success in the nine spheres. Corroboration of this finding was amply provided by other data collected during the study.

Table 3.08. Percentages of Teachers Indicating Most Success in Applying Computers to Specified Tasks.

	All Schools	Pilot School	Phase II Schools
Financial accounting	70 (24)	96 (63)	60 (17)
Management documents	66 (24)	96 (66)	55 (17)
Analysis of exam results	66 (23)	83 (54)	60 (18)
Production of exam papers	54 (20)	42 (26)	58 (19)
Handouts for students	49 (18)	57 (37)	46 (14)
Computer games by students	42 (15)	78 (51)	29 (9)
Producing school magazines	38 (13)	68 (43)	27 (9)
Computer club activities	37 (13)	38 (23)	37 (11)
Monitoring students' progress	31 (11)	44 (26)	26 (9)
Establishment	244	35	209

Note: For each of the three sets of respondents, the figures in the first column (not in brackets) are percentages of the number of teachers who responded to the item. The figures in brackets are percentages of the total teacher establishment.

Table 3.09. Teachers Indicating Most Success in Applying Computers to Specified Tasks (New Schools).

	%s of Establishment				
	P	Q	R	S	T
Financial accounting	31	13	16	13	10
Management documents	23	13	22	21	5
Analysis of exam results	27	13	22	21	5
Production of exam papers	16	23	16	26	14
Handouts for students	14	13	16	16	12
Computer games by students	22	3	4	11	2
Producing school magazines	8	3	4	16	12
Computer club activities	14	3	16	8	10
Monitoring students' progress	16	7	6	8	2
Establishment	49	30	50	38	42

At the end of Phase II, the heads were requested by the PD to submit reports evaluating various aspects of the implementation of the innovation. Three of the heads made the following statements:

School U
Three microcomputers are set aside completely for administrative purposes. The secretary uses one computer for all the correspondence. The second computer is (for the maintenance of)

students records and the rest of the administrative work. Students' records are maintained in a database which is updated from time to time. Another database file is kept by the secretary to maintain the records of the teachers. The bursar's department uses (the third) computer for accounting purposes. Students' fees records, staff salaries, budget etc. are maintained using the computer...The spreadsheet (in **Appleworks**) is used for the analysis of (public) examination results. This enables comparisons between (current) results, teacher predictions through mock exams, and results of previous years.

School R

The microcomputers have helped the administration to function much more efficiently and smoothly than before. Most of the class lists, fees collection, recurring letters etc. are done using the PC. This certainly saves time and storage facilities, and (has led to improvement in the) quality of documents. The wordprocessor, database and spreadsheet help the secretary and the bursar to carry out their work much more easily and efficiently. (Further, these programmes) help the teachers to (quickly and efficiently) prepare their tests/exams, schemes of work, marks (records), and handouts (for students).

School S

I cannot imagine what we would do without the office computer! Our secretary uses it all the time for correspondence, reports, notices, examination (papers), lists etc. Quick dissemination of information is possible now and less time is spent in typing.

USE OF THE COMPUTERS IN SCHOOL MANAGEMENT

The Pilot School

As revealed by observations and scrutiny of documents, school U was the most developed in relation to the use of the computer in school management. The head's office had been fully computerised, with the secretary using two computers for the production of management documents and correspondence, and the maintenance of databases on teachers and students. It was observed that monthly staff returns to the Teachers Service Commission were being produced from the staff database. Most of the fundamental aspects of the school's financial accounting - such as recording revenue and expenditure transactions, production of monthly trial balances, and end of year draft balance sheet and statement of expenditure and revenue - had been computerised. The bursar and his staff were fully conversant with the technology and on several occasions were observed entering financial data or carrying calculations. To underscore the improvement in efficiency arising from computerisation of the school's accounting system, on a number of occasions the head and the bursar independently stated that up to date reports on fees collection or the overall financial position could be made available within ten minutes

after a request had been made. Computerisation at school U had also been extended to scheduling. It was observed that the deputy headmaster assembled the teaching timetable using a PASCAL program which had been developed in the school. Schedules of other school activities (e.g. games and sports, and meetings of clubs) were also produced through use of the wordprocessor or the spreadsheet.

New Phase II Schools

In the new Phase II schools use of the computers for management was observed to be patchy. By the end of Phase II, the available observation data indicated that the secretaries at schools Q, R, and T were still dependent on the typewriter, either because they had not mastered the computer or they did not have easy access to the hardware. In school P, the head's secretary was observed to have made some use of the computers. For instance, in February 1988 she was observed entering the Form III history scheme of work into spreadsheet. On being interviewed, she said that up to that time she had had about 30 hours of experience on the computer. It was noted that, as she worked on the scheme of work, she regularly received operating assistance from the SMC. On being asked whether she worked with a computer every day, she said that she only had an opportunity to work with the computers "when the headmaster is away." This reply indicated that officially it had not been accepted or recognised that the new technology should be an essential tool for the secretary, a position symbolically underscored by the fact that whenever she wanted to use a computer she had to physically move to the RC. In contrast, in school S where the head had personally become an ardent user of the computer in management, the secretary had a computer in her office. Reminiscent of school U, it appeared that in school S the computer was close to replacing the typewriter in the secretary's office.

With regard to use of the computer in financial accounting, some progress were observed in schools P, R and T. School P came closest to matching developments in school U. Mainly through the efforts of the accounts clerk, in school P most of the revenue and expenditure aspects of the school's accounts (including budgeting, fees collection, staff salaries, and other items of expenditure) had been computerised by the end of Phase II. In schools R and T certain aspects of accounting were noted to have been computerised. This was especially so with regard to fees collection records, an area in which the two schools established electronic fees registers using the spreadsheet in **Appleworks**. Tentative moves were made to computerise other aspects of revenue collection, as well as the recording of expenditure.

At school S, an effort was made to computerise financial accounting, but after May 1987 the effort was discontinued. At school Q the computer was not used in financial accounting.

The reasons for the patchy development of computer use in school management are discussed in Part 4.

Computer Analysis of Students' Academic Data

Because it can rapidly handle calculations of desired statistical measures, the computer is particularly suited to teachers' manipulation of academic data - such as test scores. As indicated by a number of teachers (Tables 3.13 and 3.14), the implementation of CEPAK attempted to develop this application of the technology. In school T there was no evidence that the attempt ever got off the drawing board: the analysis of both public and internal examinations data continued to be handled manually. In school Q at least three teachers were observed to have tentatively experimented with use of the computer to manipulate scores obtained in internal tests, but there was no evidence of a school-wide effort to develop the application: as in school T, public examination results continued to be analysed manually. In schools P, R, S and U copies of computer printouts showing analyses of public and internal examination results were obtained. With the exception of school U, the analyses amounted to more than (1) keying in the grades received from the Kenya National Examinations Council or those calculated manually in relation to internal school examinations (2) calculating percentage passes, number of students attaining various divisions, and passes by subject. This generalised approach was useful in that it gave the staff an opportunity to apply the computer to the production of accurate data for the information of the school community and society at large. However, the approach - geared to summative reporting - lacked the sophistication needed if the analyses were to play a formative role in student learning.

The foregoing shortcoming in the analysis of examination data is largely explained by two factors. First, as revealed in discussions during workshops for SMCs and senior staff, teachers' knowledge and experience in educational measurement (both in terms of choice of appropriate statistical measures and understanding of cause and effect relationships) was hazy. Second, the technology available to the five new schools was limited on two counts as follows. (1) The **Appleworks** spreadsheet - which the schools were expected to use - has limitations as a statistical program. In November 1987, practical use of the spreadsheet in a workshop devoted to educational measurement revealed that use of the program is cumbersome in calculations of statistical measures such as the standard deviation (2) The random access memory of 128 Kb in the Apple IIe could not accommodate both the program and large user files, such as would be necessitated by analysis of the O level results of a school with 120 candidates.

School U was observed to have made considerable headway in using the computer to analyse performance data for formative purposes. In January 1987 observations and interviews at the school revealed that the school had developed a definite policy over systematic approaches in improving students' academic performance. In any one year, formal testing was carried out as follows. Forms 1, 2, 3 and 5 classes (i.e. those not to be entered for public examinations) took formal school examinations at the end of the first and third terms. The classes due to take public examinations (i.e. Forms 4 and 6) had only one formal internal examina-

tion conducted at the end of the second term. In addition to the internal formal examinations, each subject department was expected to carry out continuous assessment of students' progress. At the end of each term the departments used the scores from continuous assessments and formal examinations to grade each student on a five point scale, A to E. For all departments, the students' scores were processed by computer. Scrutiny of departmental computer printouts revealed that frequencies and summary statistics were calculated for each of the continuous assessment tests and the end of term examination, as well as for the aggregate scores obtained from these two sets of measures. The summary statistics consisted of percentages of students obtaining various grades and grade average points.

The foregoing grading approach - regularly discussed by all staff in each department - was geared to identifying cause and effect relationships in students' academic progress and, more important, developing measures to improve students' performance. At the end of each term, the head of department was required to submit to the head of school a written report containing (1) comments on the students' performance data for the term (2) measures the department had taken or was intending to take in order to improve achievement. The reports were discussed at the end of term staff meeting, as well as between the head of school and individual heads of departments. Scrutiny of the departmental reports relating to the second term of 1985 indicated that the system was prompting teachers to give thought to ways of manipulating some of the variables which affect students' achievement. Not surprising, most departments focused on the need to garner students' energies towards development of appropriate techniques in answering examination questions. A few departments expressed concern over the negative effect of what they considered to be an overcrowded extra-curriculum timetable. For instance, the head of French (echoing similar sentiments in art and physics) stated:

> In general, performance has fallen even that of the better students. We noticed that the same students were involved in far too many activities and therefore had less time for study and some found excuses for not attending classes...In future we suggest that school activities - such as interhouse competitions, sports, debates, quizzes, swimming galas, open day, science congress - should involve as many students as possible so that no student is overworked through participation in more than two activities at the same time.

Some departments articulated the need to motivate students by making learning meaningful and relevant to the social context. The head of commerce argued that "students should be helped to appreciate and treat Commerce as a living subject." Field visits (to museums, agricultural farms, industrial plants, power stations and cultural centres) - planned or already undertaken - were reported as sources of both motivation and real knowledge in the sciences, geography and Kiswahili. Partly as a way of increasing student motivation, the heads of biology, chemistry and Kiswahili indicated that they proposed to increase use computers with

classes. There were indications that some teachers recognised that individual differences should be taken into account in learning: in proposing remedial teaching for some of the students in Form 5, the head of mathematics stated that "for the weaker students individual attention will be provided as far as possible to get them to understand the basic and most important elements of the subject." The head of history not only articulated the importance of peer learning and students' active participation in lesson activities, but also the need for the teacher to improve his or her methodology through on-the-job research: the history report stated:

> We continued to encourage pupils to think and whenever possible, do the work themselves. We tried and shall continue trying to avoid turning history lessons into sermons or lectures. We encouraged group work and projects in all classes. The results obtained in tests this term show clearly that students understand better the notes they make with minimum assistance from the teacher than the notes they get from the teacher. In Form 2, for example I guided 2V in making notes on 'Why France lost India to Britain between 1748 and 1763.' I did not guide 2S: I went through the topic with them and then asked them to make notes. After a week I gave the two streams a test. 2S did much better in the test than 2V which I had assisted in making notes. Even those I used to call slow learners in 2S did well in the test...

The extent to which the staff at school U translated the academic monitoring system into the teaching-learning situation will be discussed in a later section. At this point the discussion focuses on the reasons as to why, in contrast to the other five schools, school U was able to articulate and develop formative monitoring as a matter of institutional policy. As indicated by the foregoing data, by July 1985 - about two years after the start of the pilot phase of CEPAK - using the computer, all subject departments at school U were following a clear policy on formative monitoring. In contrast, in the other five schools, at the end of 1988 - more than two years after the start of Phase II - the computer was only being used for generalised analysis of examination results and there appeared to be no discussion in which the analyses were systematically related to pedagogy.

It would appear that at school U, the head's educational background and personal interest in computers was the key factor in the development of a computer-based academic monitoring system. The head, appointed to lead the school in October 1982, had considerable experience as a graduate mathematics teacher and national inspector of schools. This latter position required him to systematically think through the variables involved in the establishment and maintenance of standards in schools. Participation in school inspections, curriculum development and conduct of examinations at the national level would seem to have enabled him to isolate and prioritise the factors which constitute the head's successful leadership of the processes of teaching and learning. High among his list of priorities would appear to have been the crucial

importance of using regular diagnostic evaluation of student learning as the base for improving academic achievement. The arrival of the computers provided the head with an opportunity to practically develop his knowledge of and interest in computers. He was quick to seize the opportunity provided by the computational potential of the new technology to actualise his perception of the importance systematic formative evaluation of student learning. In contrast, the heads of the other five schools lacked the rich background of the head at school U. All five had risen from classroom teaching to headship and only one (school P) had some exposure to computers at university. Thus, lacking practical knowledge of computers and the wider educational experience of their colleague at school U, the five heads do not appear to have been in a position to give high priority to computer-based formative evaluation of students' academic progress. In this regard, corroboration was provided through observations at project workshops for heads. In December 1986, the head of school U was invited to lead discussion in a heads' workshop. Among the topics discussed was the use of the computer in monitoring students' progress. The head at school U explained how in his school various statistical measures, including correlation between performance in the primary leaving and the O level examination, were used to make cause and effect inferences. The explanation was expected to raise a lot of discussion. The researcher's field report read in part as follows:

> However, the expected discussion did not take place. It appeared as if the participants felt threatened by the mention of statistical measures. Two of the participants refused to accept the possibility of a relationship between a lower and a higher examination. For example, with regard to students in her school Mrs. Kamuti stated that she had tried to compare performance in the primary leaving and O level examinations but had found that there was no relationship. Asked as to what statistical measures she had used to make the comparison, she stated that she had simply put side by side the grade lists for the two examinations. It was obvious that she had not appreciated the need to order performance data in a way that facilitates comparison.

As the session proceeded, it became obvious that the heads were at pains to ascribe poor student achievement in their schools to causes such as inappropriate pre-service teacher education, understaffing, lack of teacher commitment, student indiscipline and lengthy syllabuses.

During a November 1987 heads' workshop geared to use of the computer as an aid to educational measurement, two consultants introduced discussion on both statistical treatment of test data and the pedagogical inferences that could be made from the data. Echoing the air of disbelief revealed by the comments of several participants, one head remarked, "Can all this be done? And in a normal school!" The head then went on to tabulate some of the practical difficulties he foresaw, such as lack appropriate staff education and time constraints in the school term.

While it could not be denied that there is some merit in the heads' perceptions of factors which inhibit systematic development of student academic achievement, it appeared as if the heads of the new Phase II schools were ignorant or unwilling to acknowledge that lack of systematic professional leadership by the head is an important contributing factor. Sound professional leadership by the head not only directs the staff towards devising appropriate teaching approaches, but equally important - by setting high expectations of and aspirations among staff and students - greatly enhances the evolution of a school climate geared to quality learning (Walker 1965, Goodwin 1968, Greaves 1969, Sarason 1982).

The foregoing discussion raises a number of questions which could be generalised in relation to educational innovations aiming at the improvement of the quality of learning. To what extent does the innovator assume that the heads of the schools involved have the basic grasp of the professional requirements of headship? As opposed to the specifics of an innovation (such as introducing school staff to computers), how much time and effort should the innovator spend on the professional education of heads and senior staff? Doesn't the CEPAK experience not reveal the need for educational planning to address the issue of systematic pre-appointment and in-service education of secondary school heads? It would appear that curricula reforms, such as envisaged in the 8-4-4 system, cannot achieve substantial success unless the schools have professionally sound leadership.

PRODUCTION OF TEACHING AND LEARNING MATERIALS

In all schools it was observed that teachers consistently used the computers to produce test papers, handouts for students and teaching materials such as schemes of work. In schools T and U, three teachers (Business Education, Geography and Kiswahili) took advantage of the wordprocessor to prepare textbooks for publication. The majority of teacher-users allowed the researchers to examine the relevant computer files; thus, copies of over 100 documents were obtained. The following examples are representative:

Example 1 - School P - Exam Paper

FORM ONE BUSINESS EDUCATION TEST MARCH 1987

Answer all the following questions.

1. How does indirect production lead to specialization?

2. Give the meaning of each of the following terms:
   (a) market
   (b) price
   (c) market price
   (d) value.

3. How is the market...

(Altogether there were 10 questions in the test).

Example 2 - **School U** - **Handout in IT for Form 1**

INTRODUCTION TO COMPUTERS

Computers Are All Around You

Think for a moment about the community around: hospitals, supermarkets, airlines, banks, schools, restaurants, industries and homes - they are all affected by 'The Computer Revolution.'

Computers track and predict the weather; prepare pupils' records, employees' pay-checks, and budgets. Computers may be used in preparing and delivering instruction in schools. Increasingly, the dreary work on assembly lines is being done by robots. At the bakery the ingredients of bread, baking time and temperature may have been controlled by a computer! By quickly providing data on sales and expenses, computers help company managers in decision-making...

Example 3 - **School Q** - **A Mathematics Worksheet for Form 6**

Topic: Applied differential equations

Differential equations arise in almost any field in which the physical or abstract concepts can be coached in mathematical terms. These range from the physical sciences to the humanities. However, the KACE syllabus has a scientific bias in the treatment of this topic. In the following I have tried to present a wider variety of problems than what is offered in the textbook. One of the difficulties encountered by students is the representation of a word problem as a differential equation. A lot of practice is essential in order to gain confidence. Bonne chance!

21. The rate of decay at any instant of a radioactive substance is proportional to the amount of substance remaining at that instant. If the initial amount of the substance is m_0 and the amount remaining after time t is m, prove that...

Example 4 - **School T** - **Section of Chapter of a Textbook in Business Education**

CHAPTER SIXTEEN

BUDGET

The budget is an instrument of the estimated expenditure and revenue of the government for the coming financial year. In Kenya the financial

year begins on 1st July and ends on 30th June. The budget is presented to the National Assembly by the minister for finance in the month of June and is broadcast through the media...

Example 5 - **School R** - **Part of the Physics Scheme of Work for Form 3**

TIME	TOPIC	SUB-TOPIC	EXPERIMENT/PROJECT
Term 1 Week 1-5	LINEAR MOTION	Distance, speed, velocity, acceleration, vectors, v-t graph, eq. of motion	Ticker-time expt. Use of computer disks C1 & C231 on accelerate. form motion

Example 6 - **School S** - **Handout on Use of the Wordprocessor in Creative Writing**

The wordprocessor is one of the best aids for a student who is learning to write. He can jot down ideas, re-arrange them, write a draft, revise, edit, insert new ideas, etc. The wordprocessor gives the student the freedom to do all this without worrying about errors...

Exercise:

(Using the wordprocessor) write a composition on 'Persuasion' by following the instructions below. You are reminded to scroll up and down to refer to the instructions and notes as you write.

1. Pretend you want to convince your parents to let you buy something. Type the name of the thing you want.

2. List reasons that might convince your parents.

3. Delete all but the two best reasons.

4. List two things that will explain or prove your first reason.

5. List two things that will explain or prove your second reason.

(Through another 8 steps, the student is guided to making a first draft, revising and editing it to create a final version).

On several occasions, many of the teachers who learned to use the computer to produce teaching-learning materials claimed that the newly acquired expertise had freed them from dependence on the school typists. Highlighting one of the advantages of being able to produce one's own materials, in August 1987 a French teacher at school S stated, "I learned to type because the school secretary was so very bad with French papers." Other teachers pointed out that, at peak periods (e.g. just before the

beginning of end of term examinations) the school secretary was unable to cope with the volume of work that needed to be typed urgently.

However, teacher use of the technology to produce materials was not without problems. First, scrutiny of most of the materials produced by teachers indicated that many users were not taking advantage of the flexibility of the computer to improve on the quality of documents. Formatting and layout of documents was on the whole shoddy; punctuation, spelling and syntax errors abounded. It would appear that improvement in the quality of documents was not necessarily associated with the length of exposure to the computers: at the end of Phase II, documents produced by teachers who had been at the pilot school since the inception of the project were not markedly different from those produced by colleagues in the new schools. Second, many of the computer-produced documents merely echoed pre-innovation pedagogical approaches. For instance, most handouts continued to take the form of spoon-feeding by the teacher, while examination papers did not change from being a test of memory of facts (as opposed to being a test of higher mental processes). From the foregoing, it could be extrapolated that if use of the computer to produce teaching-learning materials was to have the desired impact on students' learning, it needed to be complemented by carefully planned discussion - in project workshops or within school subject departments - of the need for the teacher to give thought to both technical and professional quality of materials.

USE OF COMPUTERS IN FORMAL TEACHING AND LEARNING

Pre-innovation Status of Teaching and Learning

As explained in Parts 1 and 2, the computer innovation sought to effect changes in the formal teaching and learning of the disciplines in the Kenyan secondary school curriculum. By way of preparing to assess the nature and extent of the changes expected to result from the implementation of the innovation, before Phase II was launched the research team set out to establish the salient features of the teaching-learning process in the schools. In all six schools, intensive lesson observations and interviews were carried out. The observations revealed the following eleven features of the pre-Phase II teaching-learning process.

1. In most lessons the approach was didactic and teacher-centred. The amount and extent of the content to be covered in a lesson was determined by the teacher. The slant or emphasis given to the content by the teacher, or the definitions of concepts and explanations of procedures were rarely challenged by students. In most lessons students were never required to interact with the teacher. The teacher perception underlying the foregoing approach was epitomised by the following exchange observed in a Form 3 social education and ethics lesson in school S:

> Teacher: "What is a school?"
> Student: "A school is a place of learning."
> Teacher: "Yes, you have tried. Now I will tell you". Teacher

writes the following on the blackboard: "A school is a place where knowledge is transmitted by those who know to those who do not know."

2. Most lessons were devoted to providing facts, especially in the humanities and to a lesser extent in the sciences and mathematics. Reasons were rarely sought for. For instance, in a Form 3 geography lesson in school T the fact of the actual routes of roads and railways was given, but why those routes are dictated by the nature of the terrain was never investigated. Relationships with other topics or other subjects were seldom explored. The compartmentalisation of subjects seemed total, although perusal of the individual subject syllabuses reveal many common objectives and topics. Only the cognitive domain was dealt with: there was little exploitation of the psychomotor or affective domains.

3. In the majority of lessons, apart from the occasional science practical sessions, there was little peer learning. In some lessons peer learning was actively discouraged with exhortations such as, "You do your own work!" It was agonising to watch individual students in a Form 3 mathematics lesson in school R struggling in total silence and being unable to seek help from each other to solve the quadratic equation $16x^2 - 80x - 108,000 = 0$.

4. Virtually no teaching aids, apart from the blackboard or textbook, were ever used. In none of the history or geography lessons observed was a map ever used or drawn on the blackboard. Apart from science laboratories, there was rarely a chart or other exhibits to be seen in the classrooms.

5. The most common teaching strategies were lectures accompanied by note-giving, question and answer sessions, demonstrations and explanations by the teacher.

Lecturing was by far the most common method in history, geography, religious education, literature, agriculture, business education and non-practical science lessons. Lectures were frequently punctuated by the writing of detailed notes or isolated phrases on the blackboard, or the actual dictation of notes. In most lectures, facts were the main commodity made available. The most common activity of students during these lessons was note-taking, even when the notes given were taken verbatim from the textbook.

In most question and answer sessions the questions followed one another with a grim inevitability, whatever the response from the class. Usually only those students who indicated interest by raising their hands were asked to respond, while the majority of the class were "safe" from having to do any productive thinking. Teachers seemed at a loss as to what to do, apart from asking the question again, when a question was greeted with total silence from the class. Wrong answers were normally ignored, and follow-up questions to explore why a student gave a wrong answer were rare. Choice of question was often poor: for instance, in

introducing new topics some teachers were prone to asking questions which could only be answered after the students had mastered the topics.

In many lessons (e.g. in mathematics and the sciences) which involved explanation or demonstration of procedures by the teacher, key and vital steps in the explanation or demonstration were missed out. One often had the feeling that the material was so easy and familiar to the teacher that the necessity for use and explanation of individual steps did not seem obvious. In such situations, judging from answers to questions or written work in their books, students had not been able to make the conceptual jump from one step to the next. In several mathematics lessons for Form 5 classes it was observed that many teachers assumed that students had a higher and more subtle understanding of work covered in earlier forms than was actually the case.

6. Many teachers did not set a high premium on evaluating the learning taking place during their lessons. There were few instances of homework being given, and even fewer cases of homework previously given being corrected. In many lessons consolidation work was given during the course of the lesson, but in few cases was the work corrected, and only in some cases did the teacher actually check and discuss the work with students. There were few cases of a teacher re-teaching a topic, or changing direction, or extending knowledge of concepts or procedures further, as a result of the evaluation of students' work.

7. In most subjects the content was approached in a manner which isolated the skills and knowledge from real life. There was little drawing on the experience and environment of the students. For instance, (a) a Form 1 history lesson on the Portuguese in Africa, taught only a few hundred metres from Fort Jesus in Mombasa, made no reference to that building erected by the Portuguese at the end of the sixteenth century; (b) in school P, in a Form 3 geography lesson on the nomadic Fulani of West Africa, no effort was made to draw on the students' knowledge of similar communities in Kenya.

8. In the majority of lessons students sat totally passively throughout the lesson receiving the "words of wisdom" from the teacher. Occasionally, some students were moved to attempt to answer the teachers' questions, but the only time all students were really actively involved was during practical science lessons or when doing written work in their exercise books.

9. There were very few instances of teachers using a sequenced problem-solving approach to the learning of new concepts or ideas or attitudes. Students were rarely asked to suggest how a topic or situation should be approached, or to give their own views on a topic, or even to challenge an answer given by other students or to express a different view.

10. Efficient use of the time available to the teacher was rare. While most lessons began with a general aim to be achieved during the lesson or definition of a task to be carried out, many teachers were caught in full flow by the ringing of the bell for the end of the lesson. They were

thus left with no time for evaluation, or the summing up of key points, or for answering students' questions.

11. While the preceding findings paint a grim picture of teaching and learning in the schools, it must be pointed out that there were some shining examples of teachers who really brought their classes alive and who made learning an exciting experience. These teachers - unfortunately the exception rather than the rule - interacted to a very high degree with their students. They seemed to have a keen appreciation of where their students really were, tailored their presentation of new material to their students' needs, were quick to appreciate the students' learning difficulties and capitalised on new learning opportunities as they arose during the lessons.

Parameters for Evaluating Changes in Teaching-Learning

To what extent did the computer innovation help to change the teaching-learning approaches described in points 1 to 10 above? In order to be able to make a meaningful assessment of the impact of the innovation, this study assumes that the desired change should have fallen into a continuum of three steps. First, as a result of the implementation of the innovation, some teachers should have developed new perceptions of their job. Second, there should be evidence that teachers used the new technology to teach in new and innovative ways. Third, there should be evidence that there was a carry over of new approaches to lessons in which the computers were not in use.

Emergence of New Teacher Perceptions

The implementation approaches described in Part 2 nurtured the growth of fresh professional perceptions. At various forums, a sizable number of teachers were exposed to the technology, and its implications for teaching and learning. Particularly important, teachers were exposed to discussions on how the new technology could be built into teaching and learning approaches which seek to make these processes child-centred and geared to the development of problem-solving skills. This exposure was a new learning experience for the teachers and should be regarded as the sowing of new pedagogical perceptions. In this regard, it was noted that an important activity in most project workshops was the viewing, playing with and discussing some of the software provided. The mere fact of viewing software or listening to what others had to say about it provided participants with an opportunity to create new mental schemata, and thus a base for fresh professional reflection. As illustrated by the comments of a mathematics teacher on a program entitled **Geometric Pre-supposer**, the viewing of software was likely to eventually lead to development of new pedagogical perceptions. A researcher, previously a former mathematics teacher and curriculum developer, had reviewed **Geometric Pre-supposer** and reported as follows:

> This is definitely a user-controlled program. Many of the properties of plane shapes could be "discovered" by students. Relationships between sides, angles, areas and perimeters of similar figures, the relationship between circumference and diameter could likewise be explored and verified.

In a November 1988 workshop, the following dialogue took place between the project director (PD) and a mathematics teacher at school P.

> PD: "Have you looked at the **Geometric Pre-supposer**?"
> Mr Ndiomo: "Yes! We now find that you can do a lot with it. But at the beginning we found it difficult and it did not look interesting. But we looked at it again and found that you could build things on the properties of circles and do some trigonometry. It is quite powerful and you can do a lot of things with it."

Professional reflection was not confined to the viewing of good quality software. Exposure to software with obvious flaws was observed to be a source of critical awareness that such software was inappropriate, an awareness which teachers could be expected to transfer to the evaluation of other teaching-learning materials. To illustrate teachers' critical views on pedagogically poor software, two incidents are cited. One incident was in relation to a biology program entitled **Operation Frog**. The program simulates the dissection of the frog, a favourite activity in secondary school biology. Unfortunately the simulation is far removed from practice in the biology laboratory. For example, in the simulation the first step is to locate and incise the frog's heart, a procedure which would negate the learning potential in real laboratory dissections. In April 1988 the program was viewed by a group of science teachers in a project workshop. During the ensuing discussion, a biology teacher expressed himself as follows:

> I think this is a silly and useless program. You cannot tell me that I am going to allow my students to carry out a dissection that I am not going to control. Sometimes I only want students to look at particular organs. Now the computer says that (one must first look and incise) the heart.

The teacher's view was not unlike that of a researcher, a university lecturer in biology, who had independently reviewed the program and made the following critical comment:

> Uncharacteristically, the first organ to be removed is the heart. Normally you do not want to remove the heart, because without ligatures, you will fill the body cavity with blood! And this will make it virtually impossible to identify other organs. I cannot see how a student is likely to develop the skill of incising other organs precisely in a cavity full of blood.

The second incident relates to the views of two language teachers at school U. The two teachers had obviously given considerable thought to the use of the computer in the teaching and learning of languages. In June 1987, the two teachers were invited to lead discussion in a workshop for language teachers. After pointing out that a program entitled **Missing-Links** could be used in teaching spelling and some aspects of grammar, they argued that this program - together with other language software provided by the project - left out important aspects of language teaching. For instance, in a handout prepared for the workshop participants, the two teachers pointed out that the technology available in the project could not be used to teach phonology. In emphasizing the role of the teacher, as opposed to the computer, in teaching pronunciation the handout states:

> Pronunciation, particularly for beginners, is vitally important in learning a language. Pronunciation skills can be acquired through the teacher in a normal school situation. It is important for the students to obtain this necessary skill at the first stage.

The two teachers had been forced to reflect on the full spectrum of the issues involved the teaching of languages. Further on, the handout states:

> Teaching of language is a complex issue that does not only require the teacher's patience with his students but also his committed interest in teaching language as it is spoken.

Familiarity with the objectives of the innovation, even for non-users of the technology, was noted to be a source of fresh perceptions of both pedagogy and the curriculum. In a discussion between a researcher and three teachers at school U (October 1987), a history teacher who did not use computers in lessons was critical of a colleague in the same department who had developed and exposed classes to a number of unimaginative programs. In the discussion, the non-user history teacher argued that he would like to see computer- assisted lessons "where teachers and students don't just gaze at the screen and simply punch keys to move on, but where students listen, talk, discuss, write something in their notebooks, ask and answer questions, and get assignments." Another example was provided by a number of language teachers. A common complaint of non-user language teachers was that the official syllabuses could not be covered in the time allocated by the curriculum authorities and thus, given that constraint, it was inappropriate for teachers to experiment with use of the computer in language lessons. During the final plenary session of the workshop for language teachers held in June 1987, the English group and the PD engaged in a vigorous debate over this issue. A researcher noted that, in the course of the debate, the teachers found it necessary to spell out what they considered inappropriate in the official English syllabus and to make suggestions as to what improvements should be undertaken. Obviously the debate forced the teachers to reflect on the curriculum, a reflection which could have salutary outcomes both in

their teaching and in the development of syllabuses at the national level.[3]

An important indication of teacher change associated with CEPAK was evidence that the innovation had generated fresh interest in the importance of teaching aids, a sphere which had been observed to be neglected in the pre-innovation teaching and learning processes. A number of teachers were noted to have variously experimented with use of the computers as an educational technology. In schools Q, R, S and U, humanities and science teachers were observed to have used graphics programs to draw teaching-learning aids, e.g. maps (in geography and history), pie charts and bar graphs (in mathematics, economics and geography), science apparatus (in biology and chemistry). As demonstrated in a project workshop in April 1988, a language teacher (Mrs Lika) at school S had given a great deal of thought to the use of the wordprocessor in the development of creative writing skills among students. In another workshop a physics teacher from school Q demonstrated how a CAL program entitled **Science Tool Kit** could be used to simulate experiments in heat and light, thus pointing to the possibility that, in some cases, computer simulations could be an alternative to actual experimentation in the laboratory. The computer innovation was also associated with increased interest in other educational technologies. In school U, the SMC was noted to have systematically taped educational programmes telecast by the Voice of Kenya television; moreover, the SMC made the tapes available so that, using the school's video set, subject teachers could integrate the programmes into lessons. In schools P, Q and U some teachers were observed to have re-discovered the overhead projector, with some of them using the computer to produce transparencies for use in lessons.

Overall, exposure to the new technology should be seen as having created new habits in the thinking processes of teachers. Working with computers requires one to follow exact procedures. For example, to be able to use a particular program one must switch the computer on and follow a defined sequence of actions in order to activate (boot) the program. Subsequently, to bring on to the screen a display or to produce a printed document (e.g. in wordprocessing), the operator must follow a definite sequence of actions. As the user develops competence, he learns the rules that govern storing and retrieval of data; he learns how to organise his computer files into directories and sub-directories; he masters rationalised approaches in diagnosing and rectifying operational defects. Imperceptibly, the user learns that an organised structure is needed in order to get the best results from the technology. This sort of development creates in a teacher a new mental structure which is eventually bound to translate to his professional work. For example, the teacher may translate the structured approach learned in using the computer into planning and delivering better sequenced lessons.

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3. It is usual for a number of subject teachers to be invited to take part in the deliberations of syllabus subject panels at the national level.

Extent and Nature of Computer-Assisted Lessons

In the discussion on access to the technology and familiarity with software it was clearly indicated that in all six schools some teachers had conducted computer- assisted lessons, but that this application had been developed most in school U. At this point, in relation to subjects, classes and quality of the lessons, we turn to the extent and nature of computer-assisted lessons.

Table 3.10 shows the percentages of students (1988 survey) who indicated that they had attended at least one lesson in which computers had been used.

Table 3.10. Percentages of Students Attending at Least One Computer-Assisted Lesson.

Subject	P	Q	R	S	T	U	Average
Physics	13	11	13	77	27	57	32
Biology	31	53	1	20	1	60	27
Mathematics	13	11	13	8	3	60	22
English	31	19	2	16	23	10	15
Chemistry	7	5	5	5	27	54	14
Geography	8	5	7	1	5	32	10
French	2	22	0	2	1	40	10
History	1	0	0	0	5	52	9
Art	6	7	0	1	0	20	5
Agriculture	1	11	0	5	0	5	3
Religion	1	24	0	1	0	0	3
Kiswahili	2	2	0	0	6	4	2
Music	2	0	0	2	0	1	1

To an extent the data in Table 3.10 reflect the fact that the current Kenya secondary curriculum did not require a student to study all the subjects in the table: Form 5 and 6 students took 3 or 4 of the subjects, while agriculture, art, french and music were optional for forms 1 to 4 students. Nevertheless, in spite of the distortion arising from the way the curriculum was organised, the trend (corroborated by in-school observations) in the students' responses indicates that computer-assisted lessons were much more frequent in the sciences and mathematics than was the case in the humanities and languages.

In school U, most computer-assisted lessons were observed to be in mathematics and the sciences, but identifiable teachers of history, french, geography, art and economics were noted to have made inroads into using the technology in formal lessons. During a visit to school U in June/July 1987, scrutiny of the RC log revealed that over a three month period subject departments had made bookings to conduct lessons using the computers as per Table 3.11.

Table 3.11. Resource Centre Booking of Lessons in School U During March, May and June 1987.

Subject	Number of Lessons Booked (%s in brackets)			
	March	May	June	Total
Chemistry	6 (10)	24 (26)	29 (26)	59 (23)
IT	17 (29)	15 (17)	20 (18)	52 (20)
Mathematics	16 (27)	14 (15)	25 (22)	55 (21)
Physics	3 (5)	9 (10)	14 (13)	26 (10)
French	9 (15)	14 (15)	12 (11)	35 (14)
History	5 (9)	5 (6)	4 (4)	14 (5)
Biology	0 (0)	9 (10)	6 (5)	15 (6)
Art	3 (5)	0 (0)	0 (0)	3 (1)
Kiswahili	0 (0)	0 (0)	1 (1)	1 (0)
Total	59 (100)	91 (99)	111 (100)	260 (100)

Notes:
(1) The month of April is vacation time for Kenya schools.
(2) On a number of other visits to the school, it was observed that some lessons held in the RC had not been entered in the booking log. Thus, it is probable that more computer-assisted lessons (particularly in biology and art) were conducted during the three months.

Observations throughout most of Phase II revealed that the daily use of the RC for formal lessons at school U closely approximated the bookings shown in Table 3.11. Nine lessons observed during the June/July visit were illustrative as follows:

June 29	July 2
9.15 a.m. Form 1 Chemistry	8.30 a.m. Form 1 Chemistry
10.30 a.m. Form 1 Mathematics	9.10 a.m. Form 2 IT
11.30 a.m. Form 1 IT	10.35 a.m. Form 4 Physics
2.50 p.m. Form 1 History	11.30 a.m. Form 4 Chemistry
	2.50 p.m. Form 2 Physics

During a later visit (28 September 1987) five computer- assisted lessons were observed as follows: Form 1 biology, Form 2 physics, Form 5 mathematics, Form 2 mathematics and Form 1 IT.

In the new Phase II schools, the uncharacteristically high proportions of students who, according to Table 3.10, claimed to have attended computer-assisted lessons in certain subjects (physics in schools S and T; biology in schools P, Q and S; chemistry and english in school T; agriculture, french and religion in school Q) corroborated in-school observations that there were individual teachers who occasionally used the computers in formal lessons. However, as compared to school U, in these five schools computer-assisted lessons were observed to be a

tenuous phenomenon. Only the IT course at school Q (one period per week for each Forms 1 and 2 stream) and perhaps the use of the computers in physics lessons at school S was observed to be organised on a regular basis. Repeated observations at schools P, R and T indicated that during most of the second year of Phase II there was little use of the computers in the conduct of lessons involving whole classes. In schools Q and S, where the technology was observed being used in teaching some subjects, most of the lessons were for small Forms 5 and 6 classes or sections of the larger Forms 1 to 4 streams. Illustrative of this point was the observation that at school Q, a Form 1 or 2 IT lesson was organised in the RC for one half of the class while the other half remained in the normal classroom for revision work in mathematics.

All six schools were characterised by the absence of a clearly rationalised use of the technology in teaching across subjects and year groups. Analysis of data from school U is illustrative. Table 3.12 shows the percentages (by class) of school U students who claimed to have attended at least one computer-assisted lesson in eight compulsory subjects.

Table 3.12. Percentages of School U Students Who Had Attended at Least One Computer-assisted Lesson.

	Form 1	Form 2	Form 3
Biology	100	78	61
History	100	64	70
Mathematics	92	58	46
Physics	56	91	76
Chemistry	16	91	95
Geography	30	21	73
English	0	19	11
Kiswahili	0	7	10

The data in Table 3.12 show that there were discrepancies in the use of computers across subjects and year groups. In mathematics and to a lesser extent biology, use of the computers appeared to decline as one moved from Form 1 to Form 3, the implication being that computers were not being used with some of the streams in Forms 2 and 3. In both chemistry and geography the opposite was the case: Form 3 students were most exposed, while Form 2 students were more advantaged than those in Form 1. In physics, Form 2 had received more exposure than Forms 1 and 3, while in english and Kiswahili Form 1 had no exposure.

The discussion now turns to the quality of computer-assisted lessons.

A small number of innovative computer-assisted lessons was observed. Most of these innovative lessons were in school U, but there were shining examples in some of the other schools. Three examples of good computer-assisted lessons are presented below.

Mrs Anunda's Mathematics Lesson: School U - September 1987

Mrs Anunda brought a Form 2 class into the RC for a mathematics lesson. The class was organised into 6 groups, with five of them working on five computers. The sixth group (of 4 students) sat at a table in the middle of the RC and worked on non-computer exercises.

Group 1 was given a program entitled **Co-ordinate Geometry**, a question and answer revision program. The students worked through the program by typing in their answers which they then printed out. At the end of the exercise, the printout was handed over to the teacher for checking and grading. Mrs Anunda said that this approach was the basis of her assessment of group work when this type of program was used.

Groups 2 and 3 (and later group 1) worked on a program called **Logical Games**. Mrs Anunda said that the next topic for the class was going to be translations and that, in the current lesson, **Logical Games** was meant to imperceptibly introduce the mental reasoning skills and procedures used in translations. She explained, "When they come to the topic in the class they should realise that they already know the basic concepts from these games." She said that since the logical games have no correct answers as such, as the students worked through the program, her assessment of students' progress consisted of close monitoring and posing questions which made the students think of the choices of numbers they had to make as required by each screen. As the students worked through the program, they recorded on paper their selection of various numbers so that the students and the teacher could use the lists to re-work through the program and determine the logic of the choices.

Groups 4 and 5 were working on another question and answer program entitled **Pre-calculus**. The program required students to work out answers to questions such as "simplify the following." Mrs Anunda kept checking on the two groups and marking individual students' answers.

After the lesson, Mrs Anunda said that she had found three main uses for the programs available in the project. First, there were useful simulation programs which, in game fashion, she used to introduce new concepts on topics such as graphs, translations and vectors. Second, CAL programs such as **Pre-calculus** were good for revision and stimulating students to discover how much they still had to master in topics they had already covered. Third, other programs - such as **Co-ordinate Geometry** - were good for formative testing.

Mrs Anunda said that the assessment of her computer lessons varied according to the objective of the lesson for particular groups of students. She continued, "When all the students are using the same program, it is possible to structure some common questions usually given to students before or after working with the software. Some of these questions may also be included in classroom tests. This ensures that no student takes the work on the computer as (mere) playtime."

Group 6 was the remedial group. Individual students worked on problems related to binomial theories. The group took up most of the teacher's time because she insisted on finding out how each sum was being tackled. She said that she had found this sort of lesson management "very practical since it enables me to have a rest from whole class instruction, while at the same time giving me an opportunity to work with either the weak students or those who have missed lessons in particular topics due to long absence from school." She indicated that most of her groups remained unchanged for a term and that those students who needed remedial activities were always informed before coming to the RC.

In spite of her statement that the form of lesson management demonstrated gave her some kind of rest, it was noted that during this particular lesson she was actually very busy. She was not content to give the students complete choice of what to do in the lesson. While she did not object to students talking and discussing or even moving between some groups (e.g. between groups 1, 2 and 3), she insisted that certain tasks had to be completed and at the end of the lesson, she demanded written work from all students. She maintained firm discipline over the class. A boy who had come without pencil and paper was dispatched back to the classroom; he quickly returned to do the work but experienced a lot of pressure from his colleagues who wanted to move on. A girl in group 5 said that she wanted to discuss the working out of the sums with her colleagues but without writing anything on paper. Mrs Anunda snarled, "I will send you out of my class."

Mrs Anunda's lesson clearly exhibited at least five characteristics of a what a well planned and conducted lesson ought to be. First, she grouped the students for a purpose. Second, as illustrated by the provision of a variety of activities and the work of the remedial group, Mrs Anunda gave attention to the special learning needs of her students. Third, she used the computers to institute "play" as a natural learning strategy. Reporting on another computer-assisted mathematics lesson taught by Mrs Anunda in June 1987, a researcher stated:

> As an introduction to vectors, the fifth group was playing the game, **Racing Driver** on a BBC computer. The lesson was quite noisy, with a lot of talk and chat, but it was "busy noise" with most of the talk being about the content of the program. Students were exuberant and quite willing to talk and argue with one another. There was great enjoyment in the **Racing Driver** game, with the winner being loudly congratulated. Not at all like a "normal" lesson.

Fourth, while encouraging active learner participation and giving her students an element of choice of what to do in the lesson, Mrs Anunda set out and conducted a lesson which approached learning as a focused activity. She demanded written work from her students and exercised guidance through firm but reasonable class control. Fifth, as illustrated by her close attention to individuals' work in the remedial group, she placed a high premium on the need for the teacher to evaluate student learning as a lesson proceeds.

Ms Price's Biology Lesson: School O - July 1987

During the second lesson in the morning Ms Price was observed using a program entitled **Human Energy Expenditure** to teach biology to a class of five Form 5 girls. Before the lesson Ms Price had said, "I planned to give them an opportunity to use the technology for a better understanding of the relationship between diet and energy." The program enables one to calculate the calorific values of various foods. The program allows one to enter into a computer, data on the amounts of various foods eaten over a period, together with personal specifications - such as age, weight, height- and involvement in activities - such as sport, walking and sleeping. The computer then calculates the number of calories and, on the screen, indicates the extent to which the individual over- or under-fed herself or himself.

In preparation for the lesson, Ms Price had made copies of the students' worksheet and had attempted to give Kenya food equivalents (e.g. chapati[4] instead of bread) with approximate weights. She had then asked the girls to record data on the foods each ate over a week. During the lesson, each of the girls had an opportunity to enter her data into the program. The screen displays on the extent of under- or over-feeding generated a lot of giggling and discussion, with Ms Price joining in with remarks such as, "If you wish to keep slim you must eat fewer chapatis." The lesson was a beauty! The girls were overheard asking Ms Price to let them come back to the RC in the near future.

Ms Price's lesson exhibited four characteristics which are desirable in any teaching-learning situation. First, by involving her students in the collection and analysis of data, she gave the students an opportunity to experience the potential for systematic ordering of facts and information as a basis for learning. Second, she demonstrated that data and information in the students' immediate environment can be a powerful source of learning. To strengthen the affective impact on learning associated with "weight control", she guided the students to gather data on foods which they actually ate at home. Third, because the planning and conduct of the lesson were excellently carried, active learner participation did not need to be forced by the teacher, it developed naturally. Fourth, to make learning interesting and meaningful, the teacher fully exploited the resources available to her. In particular, by capitalising on the potential of the program and the computational capability of the computer, she guided her students to manipulating real life data, a feat which would have taken much longer in the absence of the new technology.

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4. Chapati is made from wheat flour. Water is added to flour which has been mixed with baking powder. After the dough has been thoroughly kneaded, bits of it are rolled flat on a wooden board such that approximately round pieces (.25" thick) are made. A shallow cooking pan is used to fry the pieces. Chapati is usually eaten together with some form of meat stew.

Mr Wakaba's Physics Lesson: School S - July 1987

Mr Wakaba was observed teaching a Form 5 class of six students. The second part of the lesson consisted in using a CAL program to revise the concept of electric circuits being in either series or parallel. To usher in the exercise, Mr Wakaba said, "Let us relax." The students moved their chairs close to the screen. Teacher: "You know how to operate. I will take a back seat while you do the work." Mr Wakaba guided the class into loading the program. As screen displays of circuits, resistance values and questions appeared, the students copied them into their exercise books. For each display of a circuit, the teacher posed questions on which sections were in series or in parallel. After about ten minutes an interesting episode developed. Pointing to a circuit diagram on the screen, the teacher tried to establish which parts were in series and which were parallel. Two students gave the correct answer, but Mr Wakaba insisted on a different interpretation. An argument ensued. In an attempt to prove that he was right, Mr Wakaba consulted some notes he had and tried to prove his interpretation on the magiboard. The students would not give in and the teacher had to agree to the compromise that the program be run "so that we find out what the author's interpretation is." After the relevant section of the program had been run, the students' interpretation was confirmed. The episode generated a lot of discussion and seemed to result in a lot of peer learning, with one girl taking a prominent "teacher" role in the class.

An interesting and salutary feature of Mr Wakaba's lesson was his conscious effort to use the computers to develop a degree of autonomous learning by his students. Acceptance of student autonomy was implicit in the opening statements, "Let us relax" and "You know how to operate. I will take a back seat." Although not without considerable embarrassment on his part, Mr Wakaba's willingness to have his "wisdom" questioned by his students was clearly demonstrated in the debate over the circuit issue. This lesson demonstrated that if, in certain teaching-learning situations, the teacher is willing to accept students as intellectual equals, the students' learning is enhanced. The healthy teacher-learner interaction, interaction among the students, and a willingness by both teacher and students to submit the circuit debate to, as it were, arbitration by the program resulted in a welcome confirmation of the students' knowledge of electrical circuits.

In addition to the characteristics exhibited in the three lessons discussed above, there is evidence that CEPAK influenced formal teaching and learning in at least three other ways. First, a number of teachers demonstrated that the new technology could be effectively used to speed up syllabus coverage. For, example Mrs Anunda, whose innovative lesson has been discussed above, was noted to have developed and used the electronic spreadsheet to speed up coverage of certain iterative operations in mathematics - such as the calculation of compound interest. Through workshops in which Mrs Anunda was invited to lead discussion, this use of the spreadsheet was disseminated to other teachers in the project. A mathematics teacher at school Q was observed to have applied this new approach in his lessons. Second, some success was achieved in

the development of team teaching. An example was provided in a lesson on statistics for biology students in school Q. In the lesson, the biology teacher for Form 5 worked with a mathematics teacher: while the biology teacher explained the biological significance of the data, the mathematics teacher explained the meaning of the statistical treatment of the data. Third, use of other technologies in formal lessons was developed, especially in school U. In this school, use of video in lessons was observed to be frequent in biology, french and Kiswahili lessons, while the overhead projector was observed being used in most non-revision lessons conducted in the RC. An important aspect of the use of video was that most of the programmes dealt with data or phenomena in the students natural and socio-economic environment.

Although to a considerable extent CEPAK favourably influenced the teaching-learning situation, there is evidence that, the examples given were not representative of practice in most lessons in the six schools.

The three innovative lessons discussed above were, in several senses, special cases. In the case of Mrs Anunda, the innovative mathematics teacher at school U, it was noted that before joining the staff of the school she had obtained a masters degree in computer studies and thus she was already familiar with the new technology. Further, on joining the staff, the head (an experienced mathematics teacher and a proponent of the ideals of the computer innovation) allocated Mrs Anunda a reduced teaching timetable of 9 periods per week. The head instructed Mrs Anunda to use the time created through her reduced load to think through the mathematics scheme of work and to develop appropriate computer applications in teaching the subject. Thus, as she explained in an interview, Mrs Anunda had plenty of time to review the available CAL software, develop mathematical applications of the spreadsheet, give attention to the planning of computer-assisted lessons and appropriately slot in use of the computer into her scheme of work. Ms Price, the biology teacher in school Q, was another exception. During the baseline study, Ms Price was noted to be one of the few teachers who was keenly aware of the need to actively and imaginatively involve students in lesson activities. In two lessons, she was observed introducing a variety of locally collected specimens and using them to make learning interesting and meaningful to her students. Moreover, in the course of Phase II, Ms Price was noted to be one of the few teachers in the project who, through wide reading, tried to keep abreast of new knowledge in her subject. For instance, she was noted to be a regular subscriber to two American magazines, **Scientific American** and the **National Geographic Magazine**, which publish articles on the most up to date advances in biological knowledge. It was no wonder that she was able to adapt the new technology and imaginatively use it in her teaching.

Mr Wakaba, the teacher of the lesson on circuits at school S, was observed to be an exception in a different way. Before conducting the innovative lesson he had not attended any of the workshops organised by the project. In another lesson, observed on 30 September 1987 his approach was observed to be far short of the pedagogical ideals propagated in CEPAK. The observer reported as follows:

> I observed Mr Wakaba conducting a Form 5 physics lesson in the RC. Mr Wakaba was using the magiboard and one micro hooked up to the large TV monitor. The lesson began with the teacher explaining some points about vectors from diagrams drawn on the board. The diagrams were merely copies of what appeared on the micro screen. There was very little interaction between the teacher and the class. It was a matter of the teacher talking and asking questions, with very little response from the class of 12 girls. Most of the work was being done on the magiboard with the teacher talking and the students listening. The teacher occasionally changed the display on the screen and read out what was displayed there. When a question appeared on the screen the students were told to do the question in their books. The teacher then pressed **Return** on the computer keyboard to show the answer. Now and then a girl was allowed to press **Return** to go to the next screen display or was asked to point out something on the screen, but the whole pace and direction of the lesson was controlled by the teacher. There was a very poor response to the teachers' questions, as if the students really did not know what was going on. But it was noticeable that while the students were working out questions on their own, there was much more interaction among them, with a lot of chatter and discussion as to what the answer to each question should be. At the end of the lesson one wondered why it had to be held in the RC. Virtually all that took place could have been done just as well in an ordinary classroom.

In some cases, the emergence of new pedagogical perceptions among teachers did not seem to have translated into the conduct of lessons. For instance, although Mrs Lika at school S had given thought to the use of the wordprocessor as a tool in teaching creative writing (and was observed articulating the possibilities in a workshop), there was no evidence that she ever applied the approach in her lessons. On the contrary, two of her french lessons - observed in September and October 1987 - were no more than unimaginative application of the computer as an electronic chalkboard. The researcher's report on the October lesson stated:

> Mrs Lika was sitting at a computer with a group of 6 girls. The teacher was the one operating the keyboard, basically using the computer as an electronic blackboard. The objective of the lesson was to find alternatives for words appearing in a passage. With reference to a french passage on the screen, Mrs Lika posed questions to the students. In order to answer the questions, the students were expected to look up meanings from dictionaries. As an alternative word was spelled out by a student, Mrs Lika typed it into the passage. For most of the time, the girls were sitting passively. Their replies, mainly from two of the six, were barely audible. Mrs Lika was sitting directly in front of the screen...obsecuring the screen from some of the students. It was difficult to see how this computer-assisted lesson was any better than an ordinary one in

which alternative words were written into a passage on the chalkboard. At least in the classroom, all students would have had a clear view of the passage.

Unimaginative use of the computer as an electronic chalkboard was not the only weakness in computer-assisted lessons. The majority of computer-assisted lessons observed during Phase II were limited to revision, with the use of question and answer programs predominating. Use of the technology to introduce new topics, or to demonstrate and/or simulate concepts which could not be shown through actual experimentation was rare. Table 3.13 shows an analysis of the teachers' responses (1988 survey) to an item which required them to indicate whether or not they had used the computer in five specified activities.

Apart from confirming observations that in all six schools, revision was the predominant mode of the majority of computer-assisted lessons, the data in Table 3.13 reveal two other trends. First, in school U about a quarter of the staff had used the technology in introducing new topics. Again confirming in-school observations, in schools P and T there was virtually no use of the computers in teaching new syllabus topics. Second, very few teachers had exploited subject software as a source of notes for students. This trend, noted in most observations of computer-assisted lessons, was further confirmed by an analysis of students' responses to an item in the 1988 survey. In a continuum of five boxes, 'Most Time' to 'Least Time', the students were asked to indicate the relative length of time they spent on six activities during computer-assisted lessons. The percentages of respondents who indicated that they spent most time on each of the activities are shown in Table 3.14.

About a fifth of the students spent most time operating the computer, an indication that most students did not have an opportunity to actually take charge of the keyboard. Overall, as compared to writing notes on the contents of the lesson, much higher proportions of students indicated that they spent most time reading the screen, interacting with classmates and listening to the teacher. Only 16% (with a surprising 8% at school U) of all students responded that they spent most time recording the content of computer- assisted lessons. While obviously screen displays

Table 3.13. Percentages of Teachers Using Subject Programs in Carrying out Five Activities in Lessons.

	P	Q	R	S	T	U	Total
Revision of work already taught	6	23	12	18	2	46	16
Demonstrations	4	13	6	3	0	11	6
Teaching new topics	0	7	2	3	0	26	5
Simulations	4	10	4	0	0	6	4
Enabling students to make notes	6	3	0	3	0	6	3
Total establishment	49	30	50	38	42	35	244

Table 3.14. Percentages of Students who Spent Most Time on Stated Activities in Computer-assisted Lessons.

	P	Q	R	S	T	U	Total
Reading the screen	53	39	43	57	46	32	46
Discussing with classmates	20	23	40	25	34	36	28
Listening to teacher	31	44	42	13	31	10	25
Operating computer	18	25	30	16	21	20	21
Writing notes	22	17	22	17	12	8	16
Reading textbooks or notes	15	12	28	7	17	6	12

had to be viewed and discussion with classmates must have fostered peer learning, the lowly place accorded to recording on notebooks the content of screen displays or the outcome of interaction with peers would appear to have been a weakness in the integration of the new technology in the overall scheme of learning. It can be extrapolated that for the great majority of students, computer-assisted lessons amounted to no more than viewing and discussing what appeared on the screen but without taking down what was being learned so that it could be integrated with knowledge obtained from other sources. In an education system dominated by the need to pass public examinations, the importance of students making written records of what is learned should not be underestimated. Students need such records for revision nearer the time for taking the examinations. Thus, if the computer innovation had to move towards centre stage in a major objective of the schools, computer-assisted lessons needed to become an important source students' notes.

According to data in Table 3.14, the 12% of students who responded that they spent most time reading textbooks or notes unrelated to the activities of computer-assisted lessons is an indication of students' boredom (on occasions noted by observers in the RCs) in such lessons.

A second indication that some teachers regarded computer- assisted lessons as marginal in the whole scheme of teaching and learning was the observation that most lessons seen in the RCs were characterised by a tendency for teachers to abandon classes to either the SMC or the computer. For instance, researchers' reports on 13 (29%) of the 45 computer-assisted lessons observed between March and October 1987 indicated that either the subject teacher was altogether absent from the lesson or, other than handing over program disks to students and giving some operating assistance, he or she did not interact with the class over the content of the lesson. For some teachers, abandoning classes to the SMC was a conscious decision, as indicated by the following two extracts from a researcher' report on discussions with two science teachers in school S (October 1987):

> (a) Mrs Gaimu's approach to taking classes to the RC is as follows. She takes half of the class to the RC and leaves the other half behind, usually in the biology lab. The teacher on

duty in the RC supervises the group on the micros (which must eliminate the potential benefits of teacher intervention during the micro session) while Mrs Gaimu works with the group in the classroom.

(b) Mr Lawari (chemistry) has not used the computers with students for anything other than viewing CAL software...He takes 20 students to the RC and leaves the rest in the classroom. Those left in the classroom or lab do normal work. The group in the RC is left with the teacher on duty there, while Mr Lawari works with the group left in the classroom.

In a number of cases teachers who were unable, on account of being busy performing other school duties or attending to personal problems, resorted to using computer-assisted lessons as a stop-gap. As shown by the following two examples, some teachers did not regard such lessons as important and thus did not give them much thought either before or after they had taken place.

Form 6 Economics in School Q - October 1987

Before the lesson, Mr Said who was also a deputy headmaster, informed the researcher that because he was busy organising the school's end of term examinations, he had organised for his Form 6 class to look at some economics computer programs. He indicated that in a later lesson, he would discuss with the students what they had learned from the programs. At the beginning of the lesson, Mr Said brought the 11 students to the RC and then abandoned them to the care of the SMC. The students divided themselves into three groups, each at a computer. The group nearest to the researcher began to look at **Price Elasticity**. Ten minutes later there was a power cut and the students left the RC. After formal lessons, the researcher tried to find out how the promised discussion had proceeded, but Mr Said seemed to have forgotten the whole episode.

Form 2 Physics in School U - September 1987

Mr Dave, who was also head of department, had an appointment with his doctor. He had asked the SMC to hand over some programs to the class and to supervise the lesson. Of the 35 students present, only 4 (two groups of boys) chose to work with the computers. One group worked on a program entitled **Astronomy**, while the second group tried to work with **Dynamic Modeling**. Students in the first group could answer none of the questions posed by the program after geometric diagrams of the solar system had been displayed on the screen. The second group had a more difficult time. The **Dynamic Modeling** disk had been handed over without a manual and the students could not make out how to proceed on the basis of the limited instructions appearing on the screen. While the two groups were struggling with the computers, the rest of the class was occupied as follows: 6 boys (in 2 groups of three) worked on a physics quiz; a group of 5 worked on a chemistry assignment; 3 students worked on a french exercise, while another 7 completed a biological diagram (in the previous period the class had been attending a biology lesson); and 3 girls spent

most of the time reading a popular women's magazine.

Computer-assisted lessons used as a stop-gap were prone to repetition, with students being required to work with the same programs time and again. This tendency was graphically illustrated in a mathematics lesson observed in school U. On arrival at the RC, Mr Choteo, the teacher, collected the relevant discs from the SMC and waited for the class to arrive. The students trickled in slowly. After eleven minutes the students assembled around the six computers set up by the teacher. Mr Choteo "sh-sh-ed" the students to some semblance of silence and informed them that they were going to work on some programs that he had already set on the computers. He asked the students to "make sure you sit at a computer that has a program that you haven't worked on before." As students wandered from one screen to another, many grumbled saying, "We have seen all these things before." One student whispered to his friends, "The man has nothing to teach." Another replied, "Again?" A group of 5 moved out of the researcher's hearing, laughing. After a lot of mumbling one student said, "Sir, we would rather go back to the classroom and work on the important mathematics for the test." After some silent reluctance, indicated by a frown, the teacher agreed and the students trooped back to the classroom.

One would have thought that with advance notice that teachers should conduct demonstration computer-assisted lessons to be observed by outsiders, some innovative lessons would have been seen. In January 1988 the PD had informed the six schools that in February he would be visiting them to observe and make a video programme of computer-assisted lessons. At the appointed time, with the PD making use of his video camera, two lessons (chemistry and physics) were observed at school U. Both lessons were characterised by absence of interaction between the teachers and the students. The chemistry lesson proceeded as follows. Half of the class (seated at desks in the middle of the RC) was required to work on exercises in the their chemistry textbooks, while the other half (in five groups) worked with a locally produced question and answer program dealing with the periodic table, salts and electrochemistry. In his report on the lesson, the researcher present stated:

> On a number of occasions the teacher attempted to give one or two hints to the groups working on the computers, but by and large he was content to stand quietly in the room doing nothing. As far as the students working on non-computer exercises were concerned, the teacher completely forgot them... Obviously teachers have a real problem of what to do with themselves if they believe that in a lesson involving use of the technology, the computer should take over.

One way of finding out whether or not a teacher considers his lessons to be central to students' learning is to scrutinise the extent to which conduct of the lessons contains evidence of prior planning. Observation of most computer-assisted lessons indicated a minimum of prior planning. Teachers in the new Phase II schools were particularly prone to treating lessons in the RC as add-ons which did not require much thought in

advance. This attitude was epitomised by the following remark from a computer-using mathematics/physics teacher in school Q:

> I do not think that any special preparation is needed before bringing classes to the RC, as long as the teacher has his disks ready.

But even in school U, where computer-assisted lessons were more common, evidence of detailed prior planning was often lacking. The following two examples illustrate the point.

Form 5 Biology in School U - September 1987

Mrs Mishe organised the 11 students in the class into four groups. She handed four programs (**Human Energy Expenditure, Reproduction, Transpiration** and **Transport**) to the groups. For sometime the group working with **Human Energy Expenditure** was engaged in an intense debate, with fingers being pointed at the screen display. Finally, one of the students attracted the attention of the teacher and asked her to give the group "the students' worksheet which the screen has suggested is needed for working with the program." Mrs Mishe then went and asked the SMC whether or not there was such a sheet. The SMC rummaged through the pile of paper on his desk and handed over the sheet to Mrs Mishe. This episode suggested that Mrs Mishe had not previewed the program as part of her preparation of the lesson. After the lesson, the researcher asked Mrs Mishe what assessment she had carried out during the lesson. Mrs Mishe said, "I noted that the group working with the **Reproduction** program had been unable to answer many of the questions. I did not look at this particular program before the lesson. I should not have given it to them because we have not done this topic yet."

Form 4 Physics in School U - July 1987

The class of 30 students was seated before the large screen linked to the BBC computer. Teacher: "The disk I want to show you today is directly connected with the syllabus and has to do with light waves and their bending in various mediums." The teacher then loaded and began demonstrating the program, **Science Topics: Waves**. However, the lesson did not proceed smoothly because the teacher was unable to quickly manipulate the program menu in order to bring on to the screen desired displays. This was particularly so when students asked questions which the teacher had not anticipated. In summing up his observation, the researcher present stated:

> The teacher had not mastered the use of this program and had not been through it to systematically establish its teaching and learning possibilities. The possibilities were there but they had not been anticipated. The lesson had not been planned such that the program could be used to demonstrate the essential aspects of the topic. The question in using programs in lessons is, how much time does the teacher need beforehand to go through the program, master the commands, look at the

possibilities and plan his lesson? I suspect a lot more time than in planning the conventional lesson where everything could be shown by a few diagrams on the blackboard. Use of a computer program does not remove the need for planning. In fact, a good computer-assisted lesson probably requires much more careful planning than its traditional equivalent.

Partly because many teacher-users of the technology did not regard computer-assisted lessons as central to the overall scheme of learning, it was not unusual to find the RC in simultaneous use by more than one class, or to find students from other classes working and often talking in the RC while a teacher was conducting a lesson with his or her class. An outcome of such a set up was that the RC was overcrowded and noisy, thereby making focused learning difficult. The following attempted french lesson illustrated the point.

Form 4 French in School Q - March 1987

During the first period of the day, four Form 5 science students came into the RC and, without a teacher, they began viewing a biology question and answer program. At the beginning of the second period, an SMC came into the RC with a female student. He gave her a disk and, from a handwritten document, she began entering personal details of students into a computer database. Shortly afterwards, Mr Murimi arrived to wordprocess a physics test. Then Mrs Jansen arrived with her Form 4 french class of 15 girls and 18 boys. At this point, Mr Murimi had to withdraw as there was no computer for him to use. Mrs Jansen was accompanied by an inspector of schools for french. All five computers were in operation. There were five groups in the room as follows:

(a) 10 girls round one micro using the word processor to type in a list of french nouns, beginning with C, together with their correct indefinite articles.

(b) 8 boys round another micro keying in french phrases using the word processor.

(c) 6 boys (1 from Form 5 science and 5 from the french class) around a micro with a biology program.

(d) 6 boys (2 from Form 5 science and 4 from the french class) round another micro with a biology program.

(e) 3 boys and 5 girls (including the one helping the SMC) round the micro with the database.

In all of the groups there was a lot of talking and chatting totally unconnected with the programs which were being looked at. In group (e) three boys and one girl were totally disinterested in what was going on: they just chatted away, with two of the boys leaning casually against the wall. In group (d) three boys at the back carried on a conversation without any regard to the computer, and the same was true of group (c).

At one stage 5 girls from french group (a) joined biology group (d), and 3 boys from french group (b) joined group (e). There was a great deal of moving from one group to another, but it was not really in search of new learning, rather in search of someone new to talk to.

Although the majority of the students in the RC were supposed to be attending the Form 4 french lesson, they spread themselves as they wished around all the computers irrespective of the activity going on at a particular computer. Mrs Jansen did not seem to mind this situation. Incidentally, earlier on, the french inspector just walked out, remarking to a researcher, "I have had enough of this." In summing up the observation of the lesson, the researcher stated:

> I would not say the students learned a lot of french, whatever else they may have learnt! While discussion and interaction are desirable, one would hope that if a class is meant to be for a specific discipline then the talking and interaction should be in a profitable direction.

The views expressed in the foregoing lesson were echoed by two other researchers. In March 1988, after a four-day observation stint at school U in which a researcher observed the RC being simultaneously used by up to three classes, she reported:

> Since most users of the RC do not plan their lessons properly, it is hardly surprising that chaos reigns. In the final analysis, teachers are not really concerned that students should learn something concrete while using the computers, as long as time is filled. And for students who might probably have been bored for 5 periods, a sixth period where they might do "almost nothing" is a well-earned gift.

Reporting a conversation with Mrs Gaimu, a biology teacher at school S, another researcher stated:

> She thinks that the students find the computers fun and a relaxation from the "normal" way of learning biology. She finds it difficult to evaluate what students learn when using the computers, but at some point she remarked, "I suppose it is like reading comic books."

Competition Between the Existing Curriculum and IT

One of the explanations for the foregoing half-hearted approaches to computer-assisted lessons was that, to an extent, the school communities perceived the computer as the object of study, as more exciting and potentially more rewarding than integration of the technology into the existing curriculum. The introduction of an IT course (subsequently developed into computer studies as an examination subject) at the pilot school and the selective introduction of out-of-class lessons in programming were partly due to belief that the project should expose students to the rudiments of computer science. Evidence of this belief

was apparent in an interview with an SMC in school P and, in school U, the relationship between the SMC, the IT and computer studies courses and plans for integrating the technology into the older curriculum. At the end of Phase II, the SMC in school P said that he had repeatedly requested the head to allocate one period per week for each of the Form 1 to 4 classes so that the students could be systematically exposed to computer studies, including some programming. However, due to pressure on the formal timetable, the head had refused to accept the suggestion. In school U the SMC who, according to the planning of the implementation, was supposed to guide the rest of the staff into integrating the technology into their normal teaching, also taught the IT and computer studies courses. By his own admission, the SMC spent most of his official working time planning and conducting lessons in these new disciplines, the implication being that he had little time left for guiding other teachers in the use of the technology. It was also observed that all IT and computer studies lessons were conducted in the RC, thus they seemed to have priority over computer-assisted lessons in other subjects. It would appear that, both practically and symbolically, computer science was receiving more emphasis than integration of the technology into the rest of the curriculum.

In schools Q, R, S and T, in some cases with the encouragement of school management, computer-assisted lessons tended to be visualised and/or used basically as a way of exposing students to information technology, rather than as a learner-centred vehicle for teaching and learning in the older subjects. This approach was clearly illustrated in school T.

During the first year of Phase II, the head in school T attempted to mandate use of the computers with all Form 1 and 2 classes. Each subject teacher in these classes was required to take his or her class to the RC once a fortnight. The teachers made an effort to follow the directive. In May 1987 a typical RC lesson (in lieu of english) was observed by a researcher who reported as follows:

The Form 1 class arrived at the RC at 9.40 a.m. The 44 students were organised into 9 groups, with five of them at computers, as follows:

Group 1: 4 students working with **Apple Presents Appleworks;**
Group 2: 4 students working with **Apple - An Introduction;**
Group 3: 4 students working with **My Dear Apple;**
Group 4: 4 students working with **Shell Games;**
Group 5: 5 students working with **A Matching Game.**

The rest of the students were arranged in 4 groups (6, 6, 6, and 5) around tables placed in the middle of the RC. These groups read books - temporarily supplied by the SMC - on information technology.

The session was supervised by an SMC, with the english teacher (Mr Mutua) in attendance.

The groups not at the micros read in silence. There was activity and interaction at the micros, as students made choices from the menus on the screens. Mr Mutua confined his attention to watching what group 3 was doing, while the SMC walked from one group to another. The students seemed quite happy with this situation and seemed well able to operate the computers without having to ask for help.

At 9.58 group 5 had finished one game, which involved matching American states with their capital cities. An indication of the approach used by students to this obviously unfamiliar topic can be gained from the fact that the group finally got the 10 matches correct after 46 trials. This group was then replaced with another group who had been reading. The new group was given quiet instructions by the SMC on how to get started. Then she changed the group at the **Shell Games**. She replaced Group 1 shortly afterwards.

It was interesting to watch the expressions on students' faces. Groups 4 and 5 were working with programs which had musical accompaniment. There was amused surprise at the sounds elicited by correct and incorrect answers: fascination and obvious interest, delight, and one or two puzzled expressions. There was quite a lot of interaction in these two groups. In the case of the groups dealing with the **Apple** programs, there was virtually no interaction. One student operated the keyboard and followed the instructions on the screen, while the others silently looked at what was on the screen and waited for the display to change. These programs were much more boring for the students and perhaps were not suitable for giving students exposure to the technology.

Shortly after 10 the SMC left the room for a while and things continued unchanged. Mr Mutua never said a word to anyone: he just looked at what groups were doing in silence. It was noticeable that, because of unfamiliarity with the keyboard, many students were having problems in typing in responses or commands.

This approach to introducing computers to classes was inappropriate on three counts. First, the lessons in the RC in which subject teachers abandoned classes to the SMC, were in most cases not related to the disciplines scheduled to be taught during the particular periods. All teachers interviewed at the school were dissatisfied with the arrangement, with most of them arguing that the RC lessons amounted to loss of teaching time in a subject. Second, there was the danger that, because the SMC did not have the time and experience to provide a variety of learning experiences in the RC, the lessons would become repetitive and therefore boring for the students. Third, the arrangement posed a threat to both tranquility within the staff and the development of the innovation: several teachers felt that the SMC had acquired too much power over subject departments, while others argued that there was no reason for them to attempt to master the technology "since the SMC has the responsibility for lessons in the RC." It is no wonder that the head decided

to discontinue[1] the approach in June 1987.

School Q had developed an IT course by the beginning of 1988. After a visit to the school in March 1988, in relation to the IT course, a researcher summarised discussions with the head and the senior SMC as follows:

> The conversations with the head and the senior SMC seem to suggest that IT is now the core reason for the computers in the school and any idea that the computers should be integrated into the general curriculum has gone by the board.

Observation of an english lesson at the school provided corroboration of the researcher's views. An english teacher at the school had assumed responsibility for the IT course. In a Form 2 english lesson conducted by the teacher, students were observed matching proverbs and their meanings using a spreadsheet which the teacher had prepared in advance. In his report, the researcher remarked, "I got the impression that the lesson was basically a way of giving the students an opportunity to experience the technology, rather than to get them to master the meaning of the ten proverbs ...This lesson could have been better taught (in terms of saving on time and increased teacher-learner interaction) if the teacher had used the computer to produce printed copies of a worksheet and then conducted the lesson in the normal classroom."

Albeit outside the formal timetable, school R also developed an IT course of sorts. In March 1988 the SMC at the school strongly argued that most teachers in the school were not interested in integrating the technology into the teaching and learning of the normal curriculum. Asked what he thought should be done to facilitate the development of the innovation, he replied:

> In order to get it going with the students, we need an IT or some vocation-orientated down-to-earth course ...Such a course might be possible on Saturday morning. It would be popular with the students...Already the Form 6 students are asking for a computer class..."

At the beginning of 1989, with the help of another teacher, the SMC mounted a course (conducted during the lunch break, after classes and on Saturday morning) in wordprocessing and database for about 40 students who were able to pay a school-mandated fee of shillings 20 per session. It was this course, rather than integration of the computers into the

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1. The head took the opportunity of the school having to accommodate student teachers on teaching practice to discontinue the arrangement. He argued that, since the student teachers had to teach particular subjects to some of the Form 1 and 2 streams, it would be unfair for parallel streams (under their normal teachers) to continue having computer-assisted lessons. However, it was observed that the regular RC lessons did not resume after the departure of the student teachers.

normal curriculum, which received prominence in the head's end of Phase II report.

Although in school S belief in exposing students to IT (as opposed to integrating computers into the normal curriculum) was to an extent diffuse, nevertheless there was evidence - albeit subtle - that it was held by some of the teacher users. Reporting on a conversation with one of the two SMCs in the school who also taught biology and had taken students to the RC for lessons, a researcher stated:

> The activities for which she took students to the RC seemed to have been very limited. For instance, her Form 4 class has been writing a joint essay on homeostasis. I got the impression that the essay was first written out in the classroom and then a group of girls would come into the RC and wordprocess bits of it at a time.

This teacher's emphasis seemed to be on giving the students an opportunity to learn wordprocessing, rather than on using the computers to give the acquisition of biological knowledge a new slant. Another teacher at school S, Mrs Mutwii (english), had attended a language workshop in June 1987. In a discussion with a researcher she said that she had "not learned anything I am not doing already. I do not think the computers can be used to teach english any better than through the methods I am currently using." Further, she claimed that there was no time for her to introduce the technology into her Form 1 and 2 english lessons. In July 1987, after formal lesson time she was was observed introducing a number of Form 1 students to wordprocessing. She justified her approach by arguing that, although she did not believe in using the computers in formal lessons "at the same time I feel that it would be a shame if the young ones are not given an opportunity to experience the technology."

Possibilities of New Approaches in Non-computer Lessons

In an article discussing the potential of new information technology in education, Dede (1987) warns that:

> The two most common errors in technology assessment are overestimating the speed of diffusion of an innovation and underestimating its eventual consequences and side effects.[2]

Bearing in mind this warning, it can not be ruled out that the positive changes in teacher perceptions, described earlier, may have imperceptibly been influencing pedagogical practice in non-computer lessons in the six schools. Moreover, it would appear that use of the computers to produce teaching and learning materials and managing the schools (including new approaches in monitoring students' academic progress)

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2. Dede, C.J. Empowering Environments, Hypermedia and Microworlds. The Computing Teacher 15.3, p. 24, 1987.

charted new directions, with positive influences on the teaching-learning process. At the risk of appearing to beg the question, it is possible that as a result of the innovation more innovative lessons than came to the notice of the research team were conducted. With regard to the future, time may be on the side of further development of positive influence of the new technology on the conduct of lessons. As pointed out, with much longer exposure to the technology, school U was observed to have staged more computer-assisted lessons than was the case in the new Phase II schools. The future could witness a similar quantitative growth in the five new schools. Equally important, the obsession with making the technology the object of study could be a blessing in disguise. It is certainly the case that before teachers begin to integrate computers into the teaching of the normal curriculum, they first need to be comfortable with the technical aspects of the technology. It could be argued that as a school community becomes familiar with technology (through use in management, production of teaching and learning materials, out-of-class activities and IT courses) imaginative use of the technology in formal lessons should increase.

Notwithstanding the foregoing doubts and suppositions of future development, what were the main characteristics of formal lessons at the end of Phase II? As in the pre- innovation period, there was a small core of teachers who conducted imaginative lessons. Some of these good teachers took advantage of the new technology to enhance the width and depth of student learning. The implementation of the innovation was of benefit to some teachers whose professional practices might never have moved from the ordinary without exposure to new ideas. For instance, there was perceptible increase in the use of teaching aids and approaches which speeded up syllabus coverage while giving students a better understanding of content and concepts. However, most lessons were observed to be dominated by the teacher-centred approaches. Lectures, notegiving, teacher questions, teacher-dictated tempo in lessons, learner passivity, unplanned grouping of students, absence of attention to the learning needs of particular students, lack of encouragement of peer learning, absence of on-going evaluation of learning during a lesson etc. remained predominant. In the crucial area of sequencing a lesson such that, in small manageable steps, the good teacher takes students from the "known" to the "unknown", most lessons were distinguished by its absence.

STUDENT USE AND RESPONSE TO THE TECHNOLOGY

Pilot Phase Evaluation

The proponents of the computer as an invention which will revolutionalise education argue that the technology provides opportunities for learning to become interactive, individualised, related to and built on the student's previous experience, thereby giving the learner more control over the process and diminishing the personal prejudices inherent in a teacher-controlled setting (Bork 1980, Papert 1980, Becker 1984, Norton 1985, Dede 1987). These claims are based on the assumption that student motivation for learning is likely to be heightened by the introduction of

the computer into the learning situation. Two evaluation reports on the pilot phase of CEPAK claimed that the foregoing assumption was substantiated. Wray (1984) stated:

> Every teacher who has used the computers in the classroom has commented on the degree to which pupils become involved in their work, both on and off the computer. All have noted that the screen does have a drawing-power, which is greater than anything else used in the classroom.[3]

In their evaluation of the pilot phase Gakuru and Kariuki (1986) found that

> ...computer assisted instruction and learning appeared to have made learning more interesting for most of the pupils. For instance, they reported that they attended lessons punctually partly with the hope of operating the computer. They also observed that solving problems with the computer can be "exciting, interesting and fun, very easy and helpful."[4]

Gakuru and Kariuki administered a written questionnaire to a sample of 111 students in the pilot school. During the Phase II study, the students' responses to two open-ended questions on initial perceptions of and general feelings about the computer were analysed afresh. The analyses are shown in Tables 3.15 and 3.16.

To an extent, the data in Tables 3.15 and 3.16 lend credence to the assertion that the introduction of computers in the pilot school had a positive effect on the students' motivation for learning. Table 3.15 shows that 80% of the sample was at the initial stage positively disposed towards the computer, a position supported in Table 3.16 by 70% of the students' general feelings about the technology. In both tables, statements which indicate that the computer is motivating ("amusing, interesting, fascinating, fun") constitute significant proportions of the students' positive perceptions and feelings. However, the context in which the students made the claims about heightened motivation, as well as other data in the Gakuru & Kariuki survey, tend to belie a conclusion to the effect that the computers greatly improved learning within the formal curriculum. First, content analysis of the statements which alluded to the motivating power of the computer shows that the majority of students who expressed this feeling were most excited by the technology in relation to playing computer games - "when you are free, to ease tension or pass time" - rather than with its use in formal lesson

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3. Wray, B.F. The Effects of Micro-Computers on the Pupils of Today and Tomorrow. Paper presented at a seminar on New Information Technology and Education: Harare Zimbabwe, p. 3, July 1984.

4. Gakuru, O.N. & Kariuki, P.W. Computers in Education at the Aga Khan Academy Nairobi, Kenya: A Study of the Impact of the Innovation, p. 4, 1986.

Table 3.15. Students' Initial Perceptions of the Computer: Pilot Phase (N = 111 students).

		%s
Computers:		
Are amusing, interesting and fascinating	46	
Would facilitate learning	21	
Are a good invention	13	
Sub-total		80
Are difficult to understand and use	9	
Are machines like any other	4	
Looked like toys	3	
Sub-total		16
No response		4
Total		100

Table 3.16. Students' General Feelings About Computers: Pilot Phase.

	Female	Male (%s in brackets)	All
Computers:			
Are interesting/fun	13 (24)	19 (22)	32 (22)
Make school work easier/ faster	17 (31)	11 (13)	28 (20)
Are good for data storage, retrieval & processing	5 (9)	9 (10)	14 (10)
Are useful preparation for future career	2 (4)	13 (15)	15 (11)
Help in solving problems	3 (5)	7 (8)	10 (7)
Sub-total	40 (73)	59 (68)	99 (70)
Are harmful/not useful	8 (14)	15 (17)	23 (16)
Vague Statements	7 (13)	13 (15)	20 (14)
Total	55 (100)	87 (100)	142 (100)

Note: The total number of students who responded to the question was 108 (38 females and 70 males). A number of respondents expressed more than one feeling.

activities. Second, note should be made of the negative reactions to the computer (16% of respondents in both Tables 3.15 & 3.16). In responses to other items in the questionnaire, the negative streak persisted. For instance, the students were requested to respond to the open-ended statements, "Using the computer with the teacher is...." and "When the teacher uses the computer..." The responses are analysed in Tables 3.17

Table 3.17. Students' Responses to Use of Computers With Teachers: Pilot Phase (N = 111).

	%s
Using computers with the teacher is:	
Very educative	58
Not very educative	20
Boring	18
No response	4
Total	100
When the teacher uses the computer:	
Lessons are more interesting	39
He explains better how to solve problems	27
Lessons become boring	22
Other/no response	12
Total	100

Although in response to both statements the majority of students thought that the teachers' use of computers made lessons more educative and interesting, about a fifth of the sample held views to the contrary.

Three general statements can be made with regard to the data in Tables 3.15 to 3.17. First, the response to the computer innovation by students at the pilot school cannot be characterised as having been wholesale acceptance. Second, students accepted that the computer could be used in lessons, but only as resource which could enrich the teacher's guidance of learning activities. Third, there were significant variations in the students' perceptions of the interrelationships between the innovation, the formal teaching-learning process and life in the society. For instance in Table 3.16 (a) 31% of the female students, as compared to 13% of the males felt that computers "make school work easier and/or faster" (b) 15% of the male students, as compared to 4% of females, felt that the introduction of computers into the school was "useful preparation for future career."

The Phase II study gave considerable attention to the nature and extent of students' exposure and response to the computer as an educational resource.

Access to the Technology

As in the case of teachers, students' access was an important factor in their use of the technology. Table 3.18 shows an analysis of the students' responses to the 1988 survey question, "How easy is it for you to get into the computer room in order to use a computer?"

Table 3.18. Students' Ease of Access to Resource Centre.

	Percentages of Students						
	P n=570	Q n=325	R n=433	S n=481	T n=157	U n=433	Average n=2399
Difficult	62.2	80.1	67.9	80.7	84.0	46.6	67.9
Easy	37.8	19.9	32.1	19.3	16.0	53.4	32.1

Note: Ease of access was in relation to the students' interest in the technology outside lesson time.

The data in Table 3.18 show that the majority of students in the new schools felt that it was difficult to gain access to the RC. In contrast, more than half of the students in school U felt that it was easy to gain access to the RC. The difference between the pilot school and the other five may partly be attributed to the fact that during Phase II school U had its threshold package of hardware doubled.

For some students access to the RC outside formal lesson time was facilitated by membership of computer clubs, but the numbers were small. Only 7.7% of the respondents in the students' sample indicated that they were members of their schools computer clubs; the percentages for the individual schools were: S - 13.1, P - 12.9, U - 7.6, Q - 4.3, R - 3.1 and T - 0.6.

Attendance at computer-assisted lessons was regarded as an important indication of access to the technology. Overall 73.6% of students who responded to the 1988 questionnaire indicated that in the course of Phase II they had attended at least one lesson in which computers had been used; the percentages for individual schools were: U - 99.5, S - 96.0, Q - 94.5, P - 83.6, T - 64.3 and R - 26.5. The percentage for school P is to an extent in conflict with the ethnographic evidence: observations and interviews at the school revealed little class use of the Phase II equipment. However, it should be noted that during Phase II, using its own resources, school P acquired 13 IBM-compatible microcomputers and set up a separate RC for them. It is thus most likely that the percentage reported here partly reflects use of the new equipment. The percentage for school T is deceptively high since, as explained in Part 1, only 35.7% of the school enrolment responded to the questionnaire.

The students were asked to estimate the number of times they had been taken to the RC for lessons during the third term of 1988. The students' responses are summarised in Table 3.19.

Table 3.19. Mean and Scatter of Number Of Times Students Used Computers in Lessons During Term 3 of 1988.

	P	Q	R	S	T	U	Average
Mean	1.37	3.78	0.30	0.40	0.08	13.40	3.04
SD	2.05	3.43	0.90	1.30	0.41	10.90	6.61

The data in Table 3.19 indicate that computers were used most in school U: in this school the mean of the students' responses implies that on average each student used a computer for lessons once per week. The low means for the other five schools indicate that, with the exception of school Q, there was little use of the computers in formal lessons. The following proportions of responding students indicated that they had not been taken to the RC for a lesson during the term: Q - 20.0 %, P - 47.3%, S - 80.4%, R - 87.8%, and T - 96.0%. The finding that 80% of the students in school Q were taken to the RC partly reflected the observed fact that by the beginning of 1988 the school had developed a formal IT course for all form 1 and 2 classes. The high standard deviations relative to the means corroborate ethnographic data on two aspects of student exposure to the technology. First, if in a set of subjects a student was taught by teachers who were computer users, the student was more likely to be exposed to the technology than was the case of a fellow student whose teachers had not adapted to the technology. Second, several teachers chose to use the computers to teach individual students or a small section of a class. This selective approach to using the computers with students was observed to take the form of lessons organised outside the formal teaching timetable, e.g. when both the teacher and students had free periods, or after the end of the formal teaching day.

Another measure of student exposure to the technology was the frequency of opportunities for students to personally operate a computer. In the 1988 survey, 50.9% of the students who responded indicated that they had personally operated the school computers on at least one occasion. The corresponding percentages for the individual schools were: U - 94.7, Q - 70.3, S - 63.9, P - 43.1, T - 36.0% and R - 15.9. The students were asked to estimate the number of times they had personally operated the school computers during the third term of 1988. The means and standard deviations are shown in Table 3.20.

The data in Table 3.20 indicate that, apart from school U, large numbers of students did not operate a school computer during the third term of 1988. The following percentages of students indicated that they did not operate a school computer during the term: U - 6.4, Q - 45.5, P - 65.7, S

Table 3.20. Means and Scatter of the Number of Times Students Personally Operated Computer in Term 3 of 1988.

	P	Q	R	S	T	U	Average
Mean	1.59	1.53	0.36	0.40	0.67	9.38	2.17
SD	4.12	2.63	2.32	1.44	2.85	9.30	5.45

- 82.7, T - 83.6 and R - 90.8. The high standard deviations relative to the means indicate the extent to which some students - either because of personal interest, membership of the computer club, belonging to classes taught by teachers-users, or selective exposure by teachers - had more opportunities of operating a school computer.

Familiarity With Technical Operations of Computers

In the 1988 survey students were asked to indicate whether or not they had personally carried out five basic tasks in operating computers. Table 3.21 shows an analysis of the responses.

Table 3.21. Students' Familiarity with Basic Tasks in Operating Computers.

	Percentages of Students						
	P	Q	R	S	T	AII	U
Started a computer	32	60	11	36	17	29	90
Loaded a disk	30	43	4	30	13	22	89
Made a new file	9	22	6	6	6	9	45
Saved a file	10	16	4	8	10	8	56
Printed a file	11	18	4	5	6	8	35
Done none of these	57	28	86	53	77	62	4
N	570	325	705	481	157	2238	433

Note: AII = Average for new Phase II schools.

The most striking feature of the data in Table 3.21 is the great difference between the new Phase II schools and school U. For instance, as compared to 62% in the new Phase II schools, only 4% of students in the pilot school had carried out none of the five operations. The widespread knowledge of the technical operations of the computer at school U is largely explained by (1) the longer period of exposure to the technology (2) a larger package of hardware (3) the fact that through the IT and computer studies courses, the school gave most of its students a hands-on experience of the technology. As compared to the other four new Phase II schools, higher proportions of students in school Q were

familiar with the five operations. This difference is partly explained by the fact that school Q developed a formal IT course for the first two secondary school classes.

Familiarity with Computer Software

In the 1988 survey students were asked to indicate whether or not they had personally used nine different types of programs. Table 3.22 shows an analysis of the responses.

Table 3.22. Percentages of Students Who Had Personally Used Specified Programs.

	P	Q	R	S	T	AII	U
CAL program	34	27	16	84	19	37	70
Computer games	48	43	9	27	21	28	83
Wordprocessor	9	46	8	19	13	16	57
Printshop	13	42	5	11	5	14	46
Mousepaint	10	19	2	3	2	7	78
Spreadsheet	4	52	7	11	3	14	26
LOGO	5	11	4	12	3	7	61
Database	4	20	5	10	10	9	26
Blazing Paddles	3	1	0	7	1	3	2
None of these	37	14	76	5	61	40	2
N	570	325	705	481	157	2238	433

Note: AII = Average for new Phase II schools.

The data in Table 3.22 shows four trends. First, as was the case with technical operations, familiarity with software was much more widespread in the pilot school. Second, as compared to the 26% in school U, 52% of students in school Q claimed to have personally worked with the spreadsheet. Observations at school Q revealed that the spreadsheet was being used in mathematics, science and language lessons, as well as being part of the content of the IT course. In school U, apart from being part of the IT and computer studies courses, it was observed that use of the spreadsheet tended to be confined to mathematics lessons. Third, relatively much higher proportions of students in schools Q and U reported familiarity with the wordprocessor and database; this finding partly reflected the observed fact that the two types of programs were relevant to the computer studies and/or IT course in the two schools. Similarly, school U in which the highest proportion of students reported familiarity with LOGO, had this language as part of its IT course. Fourth, familiarity with computer games software was reported by the highest proportions of students in schools P, T and U. This finding was corroborated by observations at the three schools that student use of the computers outside formal lesson time mainly consisted of playing games under the aegis of the computer club or during times when students were free.

Student Exposure to Programming

As opposed to the development of computer science courses which would invariably include computer programming, CEPAK was beamed much more towards integrating computers into the normal curriculum. However, the project could not ignore programming entirely. Prior to CEPAK, elements of programming were being taught in some of the schools. It was thus natural that the arrival of the computers would encourage the earlier efforts. Moreover, CEPAK could not altogether ignore programming since some understanding of its role was essential if teachers and students were to conceptualise how the technology works. With the development of IT and computer studies courses at school U, students were formally introduced to elements of programming. In the 1988 questionnaire each student was required to tick a box to indicated whether he or she had written a computer program in each of four languages. An analysis of the responses is shown Table 3.23.

Table 3.23. Percentages of Students Who Had Done Computer Programming.

	P	Q	R	S	T	U	Average
Basic	21	31	4	9	8	44	19
Pascal	5	5	1	9	1	8	5
Pilot	4	4	2	4	1	5	4
Logo	5	11	4	12	3	63	16
No programming	75	61	92	81	90	22	71
N	570	325	705	481	157	433	2671

The data in Table 3.23 show that apart from school U, where programming was taught as a component of the IT and A level mathematics courses, the majority of students in the project schools had not done any programming. The notable percentages of students in schools P and Q who had written programs in BASIC are partly explained by the fact - observed during the baseline data collection - that at these two schools some teachers had attempted to teach programming prior to the innovation. In school P, as part of the coverage of the A level mathematics syllabus, one teacher had been teaching the computer programming option. In school Q, using personal computers belonging to some of the students, two teachers (mathematics and physics) had organised a computer club in which students, inter alia learned programming. The data showing that by the end of Phase II - even in the schools where no pre-innovation interest in the aspect had been observed - programming by students had acquired some importance, would seem to reflect belief that mastery of this aspect was regarded as important. It was observed that - with the encouragement of interested teachers - the provision of hardware and programming software under CEPAK seemed to have provided individual students with an opportunity to learn the rudiments of programming in their free time. In schools P and U, several students were observed to have developed

considerable expertise in programming. For instance, by March 1988 the student leader of the computer club at school P had mastered BASIC such that he was able to set programming exercises for members of the club. The following is an example:

> Write a program that asks: "WHAT SORT OF DRINK DO YOU LIKE?" If you answer with "TEA", the computer should reply, "TEA IS VERY NICE." If you answer with "COFFEE", the computer should reply with, "COFFEE CAN BE ADDICTIVE." If you answer with "BEER", the computer should reply with "BEER IS NOT FOR YOU." If you answer with anything else, the computer should reply with "I DO NOT KNOW THAT ONE." After that reply, the computer should print one blank line and return to the question, "WHAT SORT OF DRINK DO YOU LIKE?" Finish with CTRL/RESET.

Again in March 1988, it was noted that a Form II student in school U had used BASIC to program up to a dozen multiple choice questions in geography and physics. Although from the point of view of educational measurement some of the questions were flawed, the effort was the subject of admiration by fellow classmates, some of whom were observed attempting to answer the questions.

The development of programming skills among students, though limited, was a salutary outcome of the innovation. To the extent that the efforts by student experts provided guidance and encouragement to other students, the innovation may be argued to have contributed to peer learning among students. Further, the efforts by individuals demonstrated some potential in students' control over learning activities. At another level, a few students acquired knowledge and experience relevant to further study in computer science.

Students Out-of-Class Activities

According to the data in Tables 3.08 and 3.09, a number of teachers felt that 'Most Success' in the innovation had been achieved in relation to students' use of the computers to play games, produce school magazines and to facilitate the activities of computer clubs. Observations at each of the six schools revealed that use of the computers outside formal lessons was an important opening through which some students were exposed to the technology. After a three-day visit to school P a researcher reported as follows:

> After 4 p.m. all five micros were occupied by students. Two boys were at one machine looking at a program entitled **Little Known But Useful Facts**. This was basically a question and answer program with questions asked on various topics to which students were expected to give answers. Four boys were using the wordprocessor to produce a duty roster for their class. There were six boys playing with **Mousepaint** on another machine. A girl was entering home science notes into a wordprocessor.

In September 1987, another researcher who visited school U for a full week reported as follows:

> It is quite clear that there is a large number of students who visit the RC on their own. On 28.9.87 some 27 students used the RC in non-class periods. On 29.9.87 during the computer club meeting, 18 students came in to work; earlier on the same day 16 students had visited the RC. For the rest of the week an average of 22 students per day came in to use the RC. What is interesting is that, apart from the group that came in for the computer club meeting, all other users did only two activities namely play games and use **Mousepaint** to draw.

As indicated in their end of Phase II reports, the heads of the schools considered students' use of the computers outside formal lessons to be a significant achievement of the project. Illustrative extracts from the reports of four heads are given below.

School P

Many students especially from Forms 1, 2, and 3 have been learning how to operate computers. The numbers are increasing day by day...For a long time students have had a lot of interest in computer games, especially the **Uptime** programs, **Chess**, **Backgammon** etc...(During) after school activities, students use computers to print cards, write letters to friends, learn typing and publishing newsletters...members of the computer club have been trying a bit of programming. (Some) students come in during their own free time and ask for available programs in some particular subjects. If available (the programs) are given to the (students). (The programs) have proved to be very helpful (especially) in mathematics.

School R

The computer club activities, under the guidance of the coordinator, is a crowd-puller. In fact the problem is how to keep the children away from the computers due to the heavy programme of the 8-4-4 (education system) and the lack of sufficient space in our school. To some of them the use of (the computers) might open up a new career. Certainly we are using the micros as an educational tool and ...for giving some vocational training to our students. During the past two and a half years as many as 100 students have learned how to use the wordprocessor and the database and at least 50% feel that they could be competent secretaries after leaving school.

School S

After school there is a constant stream of groups of students helped by willing teachers - the (SMC) and Mrs Mutwii - to get hands-on experience and to use available software. The 6th formers who have "free" periods are also able to go into the computer room to use the software whenever they can. (The students) enjoy (educational games such as) **World Atlas**, **Microzone discs**, **Crossword Magic**, **Where in the World is Carmen San Diego**; they (learn while having) fun.

School U

Senior students of Form 5 and Form 6 are allowed to come into the resource centre to work on any software in their subjects. This enables them to understand and revise the topics covered in the previous lessons or serves as introduction to the topics to be covered...The wordprocessor in **Appleworks** is used by students to write articles. For example, during the last National Science Congress the participants were asked to give in a full report on their projects or talks. The students used the wordprocessor to complete their reports. (They used) **Printshop** to produce covers for the articles and banners giving the name of the project or talk...The spreadsheet in **Appleworks** has been used extensively by the Forms 5 and 6 maths students to deal with their assignments in statistics...Every Friday students are allowed to have fun and games in the resource centre. Occasionally programming is also taught to interested students. The members of the school magazine committee use the computer to type in the articles given by the students for the school annual magazine.

Student use of the technology was observed to have both positive and negative outcomes. On the positive side, use of the computers outside formal lessons, to an extent enabled the schools to circumvent some of the time and pedagogical constraints imposed by the centrally mandated curriculum. First, some students were informally exposed to IT. Second, in all schools some teachers were observed working with individual students or small groups and thus experimenting with pedagogical concepts that are difficult to practise in lessons involving classes of 40+. Third, new relations in the learning situation were discernible. In the less formal out-of-class setting, as some students gained expertise with the technology they were noted to be giving guidance to their peers and, as "experts", to have gained a measure of equality with their teachers. Fourth, with regard to student control of the learning situation, the fact that individuals had an option to work with CAL and general application programs, to play educational computer games, or to learn programming gave the students an element of choice and an opportunity to work at their own pace. Fifth, playing computer games, which (as one of the most popular out-of-class activities) was observed to be the best illustration of high motivation associated with the technology, was noted to be a most welcome introduction of the concept of "play" as a learning strategy.

The production of club and school magazines gave the students an opportunity to use the technology to develop their writing skills and, in a sense, to simulate some aspects of business applications of computers in the work-place. For instance, in producing its tenth anniversary magazine, school P organised for some of its students to enter the articles into the wordprocessor using the computers in the school. In order to improve on the technical quality of the product, three teachers organised the use of the desktop publishing facilities in the project office and a camera ready copy of the magazine was printed. At that point the magazine was submitted to a commercial printer. As compared to the costs fully-pledged commercial production of previous issues of the school's magazine, the school saved a sum of about US $6,500.

On the negative side, two outcomes were observed. First, out-of-class use of the technology introduced considerable inequity in student learning. The majority of students who participated in computer activities outside formal lessons were either those favoured by teacher-users or those with a keen interest and were able to muscle their way through the severe competition associated with the limited number of computers. Second, informal use of the computers by students in a sense appeared to have marginalised the innovation's objective of effecting changes in formal teaching and learning. On many occasions, some teachers expressed the view that while out-of-class computer activities were useful for students' recreation and relaxation, they were not as important as the "serious" business involved in formal lessons. Thus, what the staff perceived as excessive use of the computers during free periods was observed to be frowned upon and often actively discouraged by the school authorities. Further, it was observed that out-of-class use of the computers was sometimes sacrificed in favour of other activities which the school gave current priority. Student access to the computers was also curtailed if there was no teacher to supervise students' activities in the RC. On their part, some students perceived the computers as a diversion from the hard work entailed in mastering syllabus content as preparation for the inevitable public examinations. On a number of occasions, after observing informal computer activities (particularly those in which no teacher was involved) the researchers expressed the view that while the students were obviously enjoying themselves and probably learning something, it was not at all clear how the activities fitted into an organised scheme of learning. From the foregoing, it could be extrapolated that (1) for some teachers informal computer activities were seen as an easy alternative to the more difficult development of use of the technology in formal lessons (2) new pedagogical approaches - such as application of individualised learning, use of "play" as a natural learning strategy, two-way teacher-student dialogue, and peer interaction among students - did not readily translate from out-of-class activities into formal lessons.

Students' Responses to Use of Computers in Lessons

In the 1988 survey, students' were asked to respond to statements which elicited attitudes towards use of computers in formal lessons. Table 3.24 shows the percentages of students who strongly agreed with six of the statements.

Some of the data in Table 3.24 show that there was a major divergence between student and teacher attitudes to the relationship between use of the technology and syllabus coverage. As shown in previous sections, some teachers held the view that use of the computers in lessons was likely to reduce the time available for coverage of subject syllabuses. In Table 3.24, responses to statements E and F indicate that the teachers' view had little support among students: only 12% of the students strongly agreed that use of computers took time away from studies and only 9% strongly felt that computer-assisted lessons were less interesting than ordinary lessons. Unlike their teachers who placed emphasis on syllabus coverage, a process which in many cases was observed

Table 3.24. Percentages of Students Strongly Agreeing With Statements on Use of Computer in Lessons.

	P	Q	R	S	T	U	TOTAL
A. The computer allows you to learn at your own speed	54	61	60	71	52	69	63
B. Learning with a computers is best for revision	56	45	64	57	55	43	53
C. Learning with a computer is more interesting than learning with a teacher	51	43	47	43	50	31	43
D. Computer program explanations are easier to understand than the teacher's	16	15	21	17	25	6	15
E. Using computers takes time away from your studies	11	20	21	6	6	7	12
F. Computer-assisted lessons are not as interesting as ordinary lessons	7	11	18	5	9	5	9

to be mechanical, it would seem that most students hankered for learning approaches which (1) made lessons interesting and sequenced (2) encouraged active participation in lesson activities, and (3) recognised individual differences while appropriately fostering peer learning. The students were particularly concerned that the learner be recognised as an individual: the responses to statement A indicate that nearly two thirds of the students appreciated that the computer has the potential to allow students to learn at their own speed.

Students' views on preferred approaches in using the technology in learning were clearly revealed in verbal interviews with individual students. In each of the following examples, the particulars of an interview are indicated by the first name of the student, his or her class and school, and the date of the interview.

An important finding from interviews with students was the observation that positive views on issues such as active participation in lessons, learner autonomy and peer learning were held by both students who had never been in computer-assisted lessons as well as those who had. The following three examples represent the views of students who had not been in computer-assisted lessons.

Lunami - Form 2 in R - 9.10.87
She has never been in a class taught with the computer, but thinks it

would be very interesting. "You would be doing something all the time and you would be involved".

Amina - Form 2 in R - 9.10.87
She has never used the computer in a subject lesson, but thinks it would make learning independent of the teacher although "for some things you would need the teacher as she knows the syllabus".

Daudi - Form 5 in P - 15.10.87
He has never been in a class taught with computers, but thinks the computers would be good for teaching as "you can learn from your friends as well as from the teacher".

The following are extracts from researchers' reports on interviews with students who had used the computer as a learning resource. The students were asked to respond as to how they felt about use of CAL programs, as opposed to attending traditional lessons, as a learning resource in normal school subjects.

Martin - Form 1 in T - 29.6.87
Asked what he preferred about learning on the computer which he doesn't get with the teacher, Martin replied, "You learn how to solve problems and you use your own mind a lot. The computer gives you more information when it asks you a question and more detail about each problem than the teacher. You can repeat the exercise or the problem as many times as you want and the computer will still say, 'very good.' You cannot do this in class because of the time. Sometimes you cannot hear the accent of the teacher. But with the computer you just read the questions and information and you will get everything."

Rakhee - Form 3 in U - 1.8.88
"A computer-assisted lesson is much better than an ordinary lesson. With the computer you can go back over things. You may not want to ask the teacher a question, so you don't. With the computer you can re-boot and do it over again."

Almas - Form 3 in U - 1.8.88
"Learning with the computer is very straightforward. It goes step by step. Teachers are so boring. Teachers don't sequence what they give you. It's the same boring teacher all the time. They keep going over the same thing again and again. The computers let you choose what you want and the speed you want to go at. I would always rather go to the computer room, especially in the afternoons when I feel sleepy. If you don't understand something with the computer you can always boot the computer again. But you can't re-boot the teacher. You may feel shy to ask a teacher questions. She has to teach the whole class and she may not worry about you. Some students are very quiet and don't like asking questions. You ask a teacher a question about something you don't understand and she repeats the same thing again. Then you are scared to ask again. You don't like asking questions, especially if the teacher has a grudge against you. The computer can't have a grudge against you."

Sophie - Form 4 in S - 1.10.87
She thought the biology programs were more interesting than the teacher. "You can move at your own speed and you can make mistakes without any problem."

Rose - Form 5 in U - 2.8.88
"What appears on the screen you can read twice, or more, and then move on. You can go at your own pace, you can go over it again. The teacher does it once and that's it. Your are scared to ask if you don't understand. I would prefer the computer to the teacher if the software was made for our syllabus. The computers are much more exciting than the teacher. The teacher goes on and on about the same point as if you were sleepy dummies."

Anne - Form 5 in U - 2.8.88
"The computer lessons are interesting. The explanations given are better than the teachers'. They tell you things the teacher might have forgotten. It helps you do the calculations for yourself. The only problem is that it is the teacher who chooses the programs. But I sometimes come during free periods and I ask for a special disk and I am given."

The students' responses revealed not only perceptions of advantages in the use of the technology but also the shortcomings of the traditional lesson. First, students felt strongly that the affective should be given due emphasis in learning situations: (a) use of the computers allows students to make mistakes without any undue criticism or sanctions being applied to them (b) some teachers do not realise students' desire to ask questions and frequent fear of doing so (c) the computers make learning interesting and enjoyable (d) the computers provide for active learning through involvement of the learner (e) teachers frequently repeat the obvious. Second, when used by the individual learner, the computer gives him or her autonomy and thus allows him or her to learn at his or her own speed. The computer allows the student to go back over content and explanations which were not readily understood the first time. In contrast, some teachers assume that their initial presentation, especially of new material, is immediately understood by all students. Third, CAL programs provide better sequencing of the development of explanations and sometimes provide more details than some teachers. Some computer programs give students hints and guidance when their first efforts are unsuccessful. Teachers are often not willing to diagnose why answers are incorrect and give hints and guidance before students try again.

Some students expressed the view that grouping - associated with the introduction of a limited number of computers - encouraged peer learning as a natural strategy. The following five examples were representative.

Pauline - Form 4 in S - 1.10.87
She likes the group discussion when operating the computers as "you can learn from one another the same as in the lab".

Mercy - Form 4 in S - 1.10.87
"Discussing things when working with the computer helps you learn from your friends. That is the way you learn after school."

Rakhee - Form 3 in U - 1.8.88
But you are in a group, so if you have difficulty you can ask you friends and discuss. You can't discuss in normal class."

Safina - Form 5 in U - 1.8.88
"The computer lessons are interesting because sometimes the teacher is so boring. Its nice to be able to discuss things in the computer lessons, because some people know better than you."

Although the computer innovation received favourable support from students, there is evidence that this support was not blind romanticism. The students were remarkably balanced in discussing the issues related to the integration of the technology into the curriculum. Under some circumstances, students had doubts about the integration of the technology into their learning. These circumstances are discussed below.

Some students perceived that there could be problems when grouping is resorted as a learning strategy. For instance, students recognised that grouping dictated by the small number of computers was not always effective. At a given time during a computer-assisted lesson, students who were not operating the keyboard became bored and passive. The following three examples from researchers' reports illustrate the point:

Alifa - Form 2 in U - 2.8.88
"I don't like groups very much. I would prefer to be on my own. If someone answers before you do, you don't get the chance to try it for yourself. In operating the computer we take turns. It is boring if you are not operating. You get fed up."

Fahima - Form 4 in S - 1.10.87
One thing she does not like about using the computer in groups is the "boredom" of sitting there when you are not operating the computer yourself. "Discussion in class is useful but you must have time to try things for yourself."

Judy - Form 5 in S - 1.10.87
She finds typing into the micro much easier than writing "because you can have second thoughts and go back and change things." She finds it boring during the french class to have to sit and watch other students correcting mistakes. "The computer is only interesting when you are operating the keyboard, otherwise it is boring. In normal classes you can talk and discuss but with the computers you have to do what is on the screen."

The following extract indicates that inappropriate grouping and personal dispositions could make the strategy ineffective.

Caroline - Form 4 in S - 1.10.87
"Sometimes slow learners can hold you back." She does not like discussion

in class as she likes being on her own. Discussion interferes with those who like "doing quiet reading on their own".

Observations at school U, where the technology was extensively used in formal lessons, indicated that repetition of programs and the theoretical bend of some lessons were major causes of boredom among students. As illustrated by the following three extracts, students felt that these problems inhibited learning.

Nasleen - Form 3 in U - 1.8.88
"You see, we are given the same programs all the time, especially in History, and we are now bored with looking at them."

Saloni - Form 6 in U - 1.8.88
On the IT course she said, "Its all theory. You don't learn how to apply it. You are not allowed to play about with the computers and find out things for yourself. I like to get the manual and see how to do things for myself. Maybe I'm funny but I like to know what goes on inside things. I like to know how the computer does things."

Dada - Form 5 in U - 2.8.88
On the IT course he said, "A lot of theory, about how the computer works and programming. I don't think you need all this to be able to use the computer. The aim should be to make it easy for the user. We need to be able to use the functions and software efficiently."

Some students recognised that there were both professional and technical hitches in using CAL programs. As indicated by the following two cases, some of the software given to students for individual or group work was above the knowledge base of the students.

Pauline - Form 2 in S - 1.10.87
She had seen one physics program which she did not like because she did not know enough physics to follow it.

Caroline - Form 4 in S - 1.10.87
She saw a business education program which was "too advanced and therefore difficult for me."

Review of software by researchers unearthed a considerable number of programs where the manuals and screen operating instructions were either vague or too technical. Two frequent comments by researchers were: (1) "the language on the screen would mean one thing to the computer and something different to the student" (2) "the program requires students to enter data or respond in a format which must be exact and technically acceptable to the computer." As indicated by the following examples, these two issues were causes of students' disenchantment with integration of the technology into learning.

Patrick - Form 6 in U - 1.8.88
"There are problems with some programs. If you don't get the answer that is expected you can't go on. You give an answer and you are stuck with

it. Even if we discuss the answers, we may still not get the answers that the computer expects. You can't ask the computer questions. You have to do what it decides you do."

Nasleen - Form 3 in U - 1.8.88
You learn more with a computer than with a teacher, although a teacher can answer questions of your own, which the computer cannot do. But with the teacher you cannot go back over things. With the computer you can. But with some programs you can't move unless you know the right answer. If you keep pressing RETURN it just keeps saying "Error! Error!" You know when you type a spelling that the computer does not know. You have to know what the computer wants you to do and you may find that you don't. But I think sometimes the teacher gives more detailed information. At times the computer only scratches the surface.

One of the reasons for student preference for computer games and graphics software, as opposed to CAL programs which concentrates on giving facts, was that after the novelty of the technology had worn off, students recognised that some of the subject software gave them no more than what they got from teachers' notes. A student in her final year of secondary school argued as follows:

Saloni - Form 6 in U - 1.8.88
On the use of CAL programs she said,"The students like games and **Printshop**, but they will not use subject programs unless they are in the form of games. The subject programs are the same as a handout from the teacher presented on the screen. Students will do those programs in class because they have to. But they will not do them after classes."

The most important perception of the innovation by students was the recognition that the teacher plays an important role in student learning and thus, in order for integration of the technology into the normal curriculum to succeed, teachers needed to play an active professional role in computer-assisted lessons. This student perception starkly contrasted with the tendency, noted in an earlier section, for teachers to regard a computer-assisted lesson as an add- on and a period during which the teacher could relax.

The students' perception of the role of the teacher in relation to the innovation is implicit in some of the data in Table 3.24. The 53% of students who strongly agreed with statement B, "learning with computers is best for revision", seemed to imply that new content must first be learned in the traditional lesson under the active guidance of the teacher. The pattern of responses to statements C and D indicate that faith in the traditional lesson was strengthened, not weakened, by prolonged exposure to the innovation. Although, as compared to the other five institutions, in school U students had received more exposure to computer-assisted lessons, there was much less faith in the technology as a learning resource. As compared to 46% of students in the other five schools, only 31% of school U students strongly agreed with statement C, "learning with the computer is more interesting than learning with the teacher." With regard to statement D, "computer program explanations are

easier to understand than the teacher's", only 6% of students in school U (as compared to 18% in the other five schools) strongly agreed. It would appear that in school U, the longer period of exposure had enabled most students to objectively evaluate the role of the technology in their learning. In the other five schools, by the end of Phase II the technology was still relatively novel, hence romantic evaluation by significantly higher proportions of students.

Although the statistical differences revealed by students' responses to statements C and D in Table 3.24 are important, they only portray a generalised picture of the reality. Interviews with students in schools P, Q, R, S and T indicated that the statistically more romantic evaluation of the technology in these schools ran the danger of obscuring the deeply held belief that the teacher had a vital role to play in the innovation. In the following extracts from reports of interviews with students in schools P, R and S, clauses which indicate the foregoing belief are underlined.

Joseph - Form 2 in P - 15.10.87
He likes learning with the computers because "you get individual attention. But if you get stuck it's better to have a teacher. You can't ask the computer questions."

Benson - Form 5 in P - 14.10.87
He thought that if CAL programs were in the RC students would look at them just because they were there. He thinks the teaching programs would be best used if the teacher interacts with the students while they are using the programs. "After all the teacher should know best what we are supposed to learn and how to use the programs."

Swabah - Form 4 in R - 7.7.87
Said she had used the computers in a physics class to do calculations. She said that the calculations given by the computer were much simpler than the ones done in class or the ones required by the examinations. She said that although she had enjoyed the computer she had found that it was silly. It can keep on repeating the same thing as long as you say "Yes". She preferred the teacher to the computer because the "teacher can know exactly where you are stuck, but the computer just asks you to read the whole thing again."

Mariam - Form 2 in S - 1.10.87
She enjoyed the computer because "you can easily go back and correct whatever you want." She was taken for a physics lesson on the computer and enjoyed the lesson and thought it was better for understanding than just having diagrams drawn on the blackboard. She thinks the computers are easy to operate with help from the teacher. She thought the computer is "interesting" and "you pay attention to it." She thinks it is better to use the micro without the teacher as "you can move at your own pace. I like working at the computer and don't want the teacher to interfere, but let me go at my own speed. The teacher can help me if I am stuck."

Fahima - Form 4 in S - 1.10.87
She thought the computer explained things better "but the teacher is useful for doing the topics first. The computer is better than the teacher because it explains step by step and you can go back. The programs are good because if you get a wrong answer it gives you help and you can try again. Very often the teacher does not give you a hint and let you try again."

Pauline - Form 4 in S - 1.10.987
What she likes about the computers is that "you can fail to understand some things and the computer allows you to go back and do it again. However, you can ask the teacher questions but you cannot ask the computer." She thinks that topics learned in class are clarified by the computer programs. "The computer would not be good for learning a topic the first time."

Mercy - Form 6 in S - 1.10.87
She finds a problem when working with the technology in that "the computer will not accept mispelling of words and you cannot query wrong answers. Sometimes the computer tells you wrong, but you know you are right. A teacher would understand that but the computer does not."

The foregoing views were not different from those exhibited by the following extracts from reports of interviews with individual students in school U. Again, clauses which indicate the students' perception of the teacher's role in the innovation are underlined.

Tasneem - Form 2 in U - 2.8.88
"The groups are nice. You get to know other peoples' views. Group discussion is easier than in class. We take turns in operating the computer and I don't get bored when I am not operating the computer. It's more interesting than with a teacher. But most of the programs are better for revision. The teacher gives the first teaching better. She goes into detail. The computer is better for revision. I'm so excited by the computers. But sometimes the computers take long to operate. Sometimes it says things that don't mean the same to you. Then I prefer the teacher."

Ntsebo - Form 6 in U - 2.8.88
"I find the computers sort of captivating. It's easier to learn with the computer. It doesn't yell at you like teachers. It is much more interesting than the teacher. But the only thing is if there is a question you can put to the teacher, you can. With the computer you can't. We are free to ask the teachers questions."

Imtiaz - Form 6 in U - 2.8.88
"The computer software gives you a different slant on things, but the computer cannot answer questions. The computers are better for revision because they cover topics you have already done in class. I think the angle of the computer is fixed, it can't react to the student."

Saloni - Form 6 in U - 1.8.88
"I don't enjoy being taught by the computer as much as being taught by a teacher. The computer can't deal with the unexpected. I suppose if you have a teacher who knows how to use the computer well then it is good because you can ask the teacher questions if you are stuck. The computer can only teach what it is programmed to teach. Sometimes there is a deviation between what the language on the screen means to the computer and what it means to you. Very often with the computer you can't jump steps if you know. You have to go through it all anyway! And there are times you can't get back to the menu if you want to skip something. There are times when you don't know what the computer wants you to do next."

The following two points summarise the discussion on students' responses to the introduction of the new technology as a learning resource. First, the technology was accepted by most students because in some ways its use confirmed their instinct that in the natural setting, learning is an active process that takes place within the individual. Second, many students were objective in their evaluation of the potential of the innovation as a learning resource. Some students articulated shortcomings arising from the size of the threshold package of the equipment, and the technical and professional mastery needed before computer software could be effectively used in learning. Most important, the students correctly judged that, as opposed to being an alternative to the human teacher, the technology should be an additional resource, but a resource whose effective adoption in the learning situation must be accompanied by the active involvement of the teacher.

SUMMARY

The discussion in Part 3 shows that (1) investment in the innovation had considerable beneficial impact on both the management of the schools and the teaching-learning transaction (2) there were a number of barriers to the integration of the technology into the work of the schools.

The beneficial outcomes of the innovation may be summarised as follows. The computer innovation had taken root, and albeit in varying degrees, was beginning to achieve the objectives stated in the project proposal. In all schools, some members of staff and students had taken an interest in the technology and were using it to undertake a number of functions related to the work of the school. The core of technology adopters, particularly among the school staff, provided an invaluable spring board for further development of the technology. Most students were noted to be highly motivated by the technology, particularly in learning situations where activities on the computer offered opportunities for active but meaningful participation. The innovation was observed to have enhanced peer learning and "play" as natural learning strategies. Among specific areas in which the innovation was observed to have had a measure of success were: (1) computer managed education (including production of administrative documents and financial accounting) (2) production of teaching and learning materials (3) monitoring of students' academic progress (4) use of the computer in students' out-of-class activities (5)

emergence of fresh pedagogical perceptions (6) use of the computer in formal lessons.

In order to place the foregoing beneficial outcomes of the innovation in perspective, Part 4 discusses management, technical, time, attitudinal, staff education and gender issues which were observed to be barriers to use of the technology by both school staff and students.

PART 4

BARRIERS TO USE OF THE TECHNOLOGY

INTRODUCTION

As indicated in Parts 2 and 3, there were a number of factors which acted as barriers to the adoption of the computer innovation. Some of these barriers were often mentioned by teachers. For instance, in 160 interviews in which teachers expressed views on why they had not used the computers for preparation of teaching and learning materials, eleven reasons were cited. The frequency of mention of the eleven reasons are shown in Table 4.01.

Table 4.01. Teachers' Reasons for not Using Computers to Produce Teaching-Learning Materials.

Reason	% Frequency of Mention
Lack of time	57.6
Poor typing skills	11.3
Avoiding conflict with other teachers	8.1
Lack of guidance within the school	4.7
No future demand for computer skills	4.4
Unwilling to do secretarial tasks	3.8
Frustrations due to loss of data	3.1
Shortage of paper in the school	2.5
Computers too difficult/complicated	1.9
Involves extra work	1.3
No follow-up to workshops	1.3

The teachers' reasons for not using the technology could be regarded as perceptions of constraints in the innovatory process in five broad areas, namely school management, technical issues, time, attitudes to the technology, and the teacher education component of the project. The effects of constraints in the innovatory process were not confined to the school staff: either directly or indirectly, the students in the project schools were affected. In using the technology, students incurred a number of opportunity costs. Further, gender bias was observed to have negatively affected student exposure to the technology.

SCHOOL MANAGEMENT CONSTRAINTS

Lack of Policy Over Computer Use in School Management

In Part 3 it was pointed out that in the new Phase II schools, use of the technology in school management was patchy. For instance, there was only limited use of the computer by secretaries in schools P, Q, R, and T. The heads of these school were quick to recognise the fact that the computer could produce management documents of high quality. However, given that the secretaries were either not competent to use the computer, or had no easy access, or were busy with other work, the heads resorted to requesting the SMCs and other teacher-users to undertake what was in essence the secretary's work. In July 1987, one SMC at school T was noted to have been asked to undertake the wordprocessing of most the examination papers due to be taken at the end of the term. At a workshop in August 1987, the SMCs at four of the schools complained that they had been overburdened by administrative chores and were thus unable to give adequate time to the development of the professional aspects of the innovation.

In Part 3 it was pointed out that, with regard to use of the computer in financial accounting, there was little positive development in schools Q and S. As far as school Q was concerned, at the beginning of Phase II the school bursar was close to retiring and, with the acquiescence of the head, she resisted adoption of the technology. At the beginning of Phase II, the bursar at school S enthusiastically embraced the new technology and began to use the spreadsheet for some of the school's accounting records. However, in May 1987 she left the school. The new bursar attended a number of relevant project workshops and on occasion promised to continue with his predecessor's efforts to develop use of the technology. But by the end of Phase II he had not done much. In the final report on the project the head stated as follows:

> ... due to changes in staffing in the Accounts Section, there has been little progress in this area. The new bursar and his staff have been introduced to the computers but they are still in the initial (or should I say inertia) stage. It is hoped that during the holidays, with less pressure of daily routine, they will spend more time and create up-to-date database files for all the students as well as for suppliers.

Thus, in schools Q and S, failure to adopt the technology for accounting purposes was associated with unfavourable dispositions among the individual members of staff involved.

To an extent, personal dispositions of the accounting staff in schools R and T may have hindered the development of the computer as central tool in financial management. However, negative attitudes among school personnel was only a partial explanation. Although in the two schools certain aspects of accounting were computerised, it was observed that there was reluctance to do away with the cash books and ledgers kept manually. This reluctance would seem to have been associated with

factors inherent in the school system. The heads of the new Phase II schools appear to have been unwilling to make policy requiring the accounts staff to use the computers. As indicated above (1) the heads of schools Q and S were content to leave their bursars to make the decision whether or not to use the technology (2) in schools P, R and T the adoption of the technology as an accounting tool had initially resulted from the interest of individual members of accounts staff. In schools P and R, the initiative had been taken by two relatively junior accounting officers - accounts clerks in both cases - and not by the bursars who headed the accounts sections. The heads' unwillingness to articulate school policy over the issue would seem to have been associated with two factors. First, there was uncertainty - as pointed out by the head at school S and the bursar at school T - as to how use of the technology would fit into existing accounting instructions in public schools. For example, accounting instructions issued by the Ministry of Education (Republic of Kenya 1975 & 1979) were quite specific as to what books of accounts should be kept, and what form draft balance sheets and statements of revenue and expenditure should take. Apparently the heads were unwilling to assume that these paper and ink documents could be replaced by electronically produced documents. Second, the computer as a tool in accounting was introduced to the new schools in Phase II under circumstances different from those pertaining to school U. In school U, a private school which was not encumbered by government accounting instructions, the computer had been introduced by a resident project director who had the support of a convinced head (Papagiannis 1985). By the end of the pilot phase, under the guidance of the PD, the accounts section had not only acquired a computer for its sole use but also had purchased and adopted appropriate accounting software. In contrast, with reduced input from a PD stationed away from the schools, the new Phase II schools were expected to develop application of the technology using a program which was not tailor-made for school accounts.

Uncertainty Over the Role of School Media Co-ordinators

As in the case of use of the technology in school management in the new Phase II schools, in all six schools, either unwittingly or by design school management did not clearly spell out the relationship between SMCs and the rest of the staff. This uncertainty was a major barrier to the dissemination of the innovation at the school level.

In all six schools, it was observed that there was tension and often friction between the SMCs and some of the other members of staff. In 43 of the 276 interviews held with teachers, opinions about the role of SMC were expressed. Only 12% of teachers' opinions were to the effect that the SMCs had helped other teachers to come into grips with the innovation. Unfavourable opinions included comments to the effect that the SMCs: (a) were uncooperative and unwilling to help other teachers (b) caused personality clashes with other teachers (c) unnecessarily restricted the use of the RC (d) were guilty of empire-building and hoarding of expertise (e) were not qualified for the role. On several occasions, researchers recorded opinions such as represented by the following three extracts from field reports:

English Teacher at School T - June 1987
Many of the teachers do not approve of (one of the three SMCs) because she is independent minded and often moody. Some of the teachers with university degrees feel that she is also not adequately qualified. Teachers are unhappy because the SMCs have converted the computer room into their personal offices. The SMCs even refuse to sit in their usual places in the staffroom, spending almost all their free time in the RC. Teachers find this practice intimidating. Coupled with this is the arrogance that the SMCs display whenever they are asked to assist others.

Mathematics Teacher at School R - July 1987
He said, "There are some people here who want to keep the computers to themselves because then they can show they are better than the rest of us." He complained of rationing of paper. Whenever he wants to get continuous stationery, the SMC tells him, "It is for official use only. I have very little paper left."

History Teacher at School U - September 1987
Teachers feel that the SMC is having a negative impact on those teachers who seriously want to learn the technology. He has subtle ways of discouraging teachers, such as: making an appointment with a teacher at four and then disappearing; refusing to hand out blank disks or to duplicate disks while promising to do so soon; backbiting teachers about their ignorance of computers and software; fiddling with connections to the computers so that some are "out of order" when some teachers want to use them, especially when there is no class booking after 4 p.m.

It was severally observed that in some cases the accusations leveled against SMCs were valid. The following two extracts from reports on observations at the RCs of two of the schools are illustrative.

Observation at the RC in School S on 2.7.87
Without realising it, the SMC illustrated the sort of unfair advantage in relation to other teachers that a media co-ordinator could create for herself. She said that although the French keyboard micro had on occasion malfunctioned "it is not much of a problem at the moment. I have labelled it as out of order because I want to make sure that when I bring in my French students, it is not being used by somebody else."

Observation at the RC in School T on 22.3.88
The SMC was observed several times seated in the RC doing her own work, without any effort to help students who were also in the RC. She was also not very encouraging in her comments to two teachers who were practising wordprocessing. She sarcastically asked them, "Are you still doing the same thing you were doing this morning? When are you going to finish?" She

was also extremely harsh to students who wanted to use the RC during lunch break and after formal lessons. To students from the Wildlife Club who wanted to work with the computers: "Doesn't your patron have a watch? Look at the time. I am closing this place just now. I have other things to do. You know that I can't leave you here."

In all six schools it was observed that, the SMCs together with other early adopters of the technology tended to behave as an exclusive club, often derisive of colleagues who had not taken interest in the computers. At the same time, members of this club of "experts" were impatient when a novice was unable to readily follow operating instructions, which in some cases were given far too rapidly and in the arcane language of the computer specialist. An outcome of the foregoing attitudes of SMCs and the exclusive club of early adopters was to discourage some teachers who may otherwise have taken to the innovation. With reference to school S, the PD's Quarterly Summary for October to December 1987 referred to this outcome as follows:

> The number of regular (computer) users seems to be 4 to 6, and it may be that it is becoming a "closed shop." Certainly a number of teachers have now been put off by the attitude of the co-ordinator, who openly suggests to them that the girls are better than them.

The PD's opinion is corroborated by researchers' reports on interviews with two teachers in school S, as follows:

> Art Teacher at School S on 29.9.87
> He said, "The SMC regards the RC as her empire and puts serious constraints in the way of those who want to use it." Rationing of paper and probing into personal and private work being done by the teacher were given as two examples of such constraints. He believes that the co-ordinator's personality has turned people off using the computers.
>
> Mathematics Teacher at School S on 29.9.87
> Said she had a feeling that classes were not welcome in the RC. "You see the problem here, although I should not say it, is that we are not encouraged to use the computers. If the RC belongs to one teacher what do you do?"

The view that individuals appointed to the new position of SMC inhibited the innovation presented only one face of the coin. Although negative aspects of the personalities of some of the SMCs were clearly not helpful in the attempt to get school staff involved in the innovation, there were important causal factors inherent in the new position. For instance, as indicated elsewhere in Part 4, perceptions that at the school level the innovation was under-provided and security considerations were factors which contributed to restrictions imposed by the SMCs. Time constraints and the status of the SMC were other important factors. After carrying out intensive interviews in relation to the role of SMCs during the first

six months of Phase II, in March 1987 a researcher expressed the following opinion:

> The implementation strategy of letting people come if they are interested and then relying on the early adopters to stimulate interest does not work. The interested ones are usually heavily involved in other school activities and do not have the time to take on the role of innovators. Furthermore, their influence as innovators depends heavily on their standing in the school. If they are too successful, this may in itself breed jealousies which may in fact hinder their role as innovators among those who are too disinterested to bother.

There is evidence that the SMCs were aware of the problems alluded to by the researcher. In August 1987, after a five day workshop for SMCs, the PD made the following statements in his written report of the proceedings:

> The co-ordinators suggested that they would be willing to take on more responsibility not only for the development of the use of computers in the schools but also to assist with general staff development programmes. However, they would need the active support and guidance of the head and administration not only for any extended role but also for the various roles which they were at present required to play.
>
> They suggested that due consideration needs to be given to their time allocation and work loads. In particular, they should not be seen as the willing "donkeys" onto whom more responsibility could be placed. Some of the (other duties currently undertaken by SMCs) should be shared out more equitably. Some form of recognition of their services would be helpful as further motivation.
>
> It is also necessary for the head to ensure that the teachers who are computer literate do not become extensions to, or replacements for the various clerical help which a school employs. When necessary the teachers can help to set up a system, but the continued working of a clerical system should be done by the appropriate (non-teaching staff).

With regard to time, in all six schools the SMCs regularly complained that the demands made on the new position were such that it was not possible for the appointees to make satisfactory responses. The following extracts from researchers' field reports illustrate the point:

> <u>School U - January 1987</u>
> The SMC feels he is over-burdened. In addition to co- ordinating the innovation he has to teach IT and computer studies, both new subjects which require a lot of preparation.

School P - March 1987
The SMC stated that at times he is over-burdened by duties that should be done by the school secretary. He quoted an incident where he finished an urgent management task on the computer at 3 a.m.

School R - March 1988
The SMC, together with (two other early adoptors of the technology) expressed concern that requests from the head to help in management was taking an inordinate amount of their time and were consequently beginning to undermine development of the technology in directions more central to the teaching-learning process. The SMC indicated some frustration at all the extra secretarial duties he is involved in. He said that on one occasion he had to wordprocess 20 foolscap pages of school rules for the head...He did the results analysis on the spreadsheet...He did the list of selected students on the database. All correspondence about computers goes to him. He compiles the quarterly reports which are merely signed by the head. He feels that a lot of this work should be done by the school secretaries.

To some extent, the SMCs' perceptions of their status within the staff prevented them from taking a more active role in the implementation of the innovation. The SMCs felt that while appointment to the new position gave them onerous responsibilities, it did not give them corresponding authority to compel other teachers to get involved in the innovation. A number of researchers' field reports contained statements such as the following three:

School U - January 1987
(The SMC) says that he does not have a high status in the hierarchy of the school's management.

School Q - March 1987
After the December 1986 SMCs' workshop, (one of the SMCs in the school) was willing to help other teachers to learn the technology, but he feels that he cannot really succeed for a number of reasons. He is not even a head of department. As an ordinary teacher, he has no control over other teachers. He has no formal authority to persuade other teachers to go to the RC.

School S - June 1987
The two SMCs did not feel that they could tell other teachers about available software, as it was not an easy thing to do. The list of software in the project library was displayed in the RC notice board. But, since the SMCs did not know what topics the various programs may be relevant for in the various subjects, they did not "feel like bothering the teacher who has refused to come and see for herself."

Without recognisable authority within the staff, the SMCs were often

treated as easy scapegoats for what appeared to be wrong with the innovation. In particular, teachers who were anxious about the technology or were unwilling to change their pedagogical perceptions and practices in line with the innovation, were quick in placing their failure at the SMC's door step. With reference to this tendency among non-users of the technology a teacher in school T expressed himself as follows:

> English Teacher at School T on 29.6.87
> Teachers will create any excuse so as to keep to their habits of teaching. The questioning of the roles and power of the co-ordinators is sometimes an excuse. Some have complained about the selection of teachers to attend project workshops, often arguing that if there is a specially trained group, other teachers should not be forced to teach with the computers.

Tension between SMCs and other members of staff had the effect of undermining the implementation of the innovation, a situation which considerably worried the implementation team. With reference to school U, the PD's Quarterly Summary for July to September 1987 stated:

> The SMC ran an apparently successful in-school workshop during the first part of August...The feedback from this workshop is however still complicated by the personality interface existing between the other teachers and the co-ordinator.

Innovation-related tensions within school staff constituted a cost in relation to the overall school climate and society at large. Charged relationships between adoptors of the technology and other teachers brought to the fore-front factionalism latent in Kenyan schools and society. In schools Q, R, S & U where some of the most prominent users of the computers came from immigrant communities, teachers indigenous to Africa were quick to point to a "monopoly of the technology" by presumed foreigners. School T, with a staff which was wholly of indigenous African origin, did not escape factionalism: some of the teachers from central and eastern Kenya expressed themselves as being kept out by early adopters - among them two SMCs - from western Kenya. It was noted that the factionalism in school T reflected ethnic tensions observable in Kenyan society. If one of the social goals of education is to promote human understanding through reduction of ethnocentricity, by fueling racial and tribal tensions among school staff, the computer innovation constituted a major cost to society. It is not unreasonable to assume that racial and tribal tensions among the staff, either consciously or sub-consciously, were transmitted to the student body.

With regard to school climate, the tensions undermined staff unity. Teachers involved in factionalism tend to spend a lot of their time and energy waging cold wars. In the process, pursuit of the objectives and goals of the school are relegated to a lowly second place. For instance, in three of the schools in CEPAK, the heads spent a lot of time trying to reconcile opposing staff factions partly feuding over the computers. In spite of this expenditure of time, two of the heads expressed themselves

as unable to heal differences of a personal nature, particularly where the opposing groups consisted of teachers who were in other ways good workers.

TECHNICAL ISSUES

Inhibiting technical factors included problems in the procurement and maintenance of equipment, imbalance in the threshold package of equipment, clashes between a central project library and the centrally-mandated curriculum, shortcomings of the new technology as an educational resource, and dearth of keyboard skills among school staff and students.

Problems in Procuring and Maintaining Equipment

Donor funding made available the foreign currency necessary for purchase of the technology without the project having to compete with other national import needs. However, in spite of the foreign exchange facility provided in CEPAK, importation of project equipment was not without snags. Problems were experienced due to the fact that the project was isolated from the source of the technology in the industrial North. First, the lead time between placing orders and receiving the goods was often considerable. With reference to this problem, the PD in his Quarterly Summary for July to September 1988 stated:

> It was noted that it was still taking up to three months for material to arrive even though all was now being ordered for air delivery.

Second, selection of new software for purchase had to be wholly based on catalogues. The project was too far away for the PD to ask for demonstration copies. Moreover, there were few local non-project schools which could provide first-hand information on new software. Partly as a consequence (1) in some subjects and general application areas, a certain amount of duplication of software took place (2) in some cases, software which according to the catalogue had appeared suitable was purchased but subsequently proved inappropriate or difficult to use.

Third, as illustrated by the case of the colour monitors acquired by CEPAK[1], isolation from the industrial North adversely affected CEPAK in relation to the acquisition and maintenance of hardware. Going by the statements of the manufacturers, 22" colour monitors were purchased because they were thought to be wholly compatible with the Apple computers. Subsequently it was found that, when connected to the Apple computers, the colour function did not work. Attempts by the PD and local dealers to rectify the fault were unsuccessful. It was obviously too expensive to transport the monitors to the dealers in Europe. A similar situation arose with regard to 12" colour monitors purchased for

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1. The colour monitors provided to schools were products of manufacturers other than Apple Inc.

connection to the Apple computers. Either because of weather conditions or some other reason, the monitors given to the two schools at the coast malfunctioned repeatedly. The local Apple dealers were unable to rectify the fault. The malfunctioning of the colour monitors meant that in some situations, software which depended on colour could not be effectively used. Observations and interviews in the schools indicated that the inability to use colour was frustrating to those involved in the implementation. In a report on an interview with the PD and the head of school S, a researcher stated:

> The head remarked that they could not get colour on the large monitor. PD replied, "Yes, there is some problem. They cannot fit them up. But you can use it with a video." But the school did not have a video.

The problem associated with CEPAK's isolation from the industrial North was probably more acute in relation to the 3.5" disk drives provided under the project. It was observed that, as compared to the computers and other peripherals, the 3.5" disk drives were more prone to breakdowns and that the cost of repair was much higher. In March 1988 the SMC at school R said that 4 of the 3.5" disk drives provided to the school had been irreparably damaged. In an interview (February 1988) the PD confirmed that the disk drives had been a major problem. The PD also attempted to explain the root causes of the problem. The researcher's report on the interview stated:

> The PD said, "(The local Apple dealers) could not quickly get parts from Apple. They have ordered parts for 8 drives. I was told that parts for seven drives arrived last week." The PD brought out two important points with regard to the malfunctioning of the 3.5" disk drives. First, "schools in third world countries should avoid purchasing leading edge technology. When supplied to CEPAK, the 3.5" disk drive was a new product in the market, thus in a sense the project was used as testing ground." Second, the necessity of replacing a substantial part of the drive seemed to underscore the fact that, "as computers become more powerful, problems of cheap repair are increasing because the machines are becoming more complicated. As happened in the encroachment of electric fuel injection systems (as opposed to the carburetor) in motor vehicles, more powerful computers seem to be dictating repair in terms of replacements of whole chunks instead of only tiny bits."

Scrutiny of CEPAK's maintenance records revealed that between September 1986 and October 1988, the local Apple dealers were paid the equivalent of US $6,605 for repair of project computer hardware. Out of this amount, $4,734 (72%) was in payment for repairs on disk drives.

Imbalance in the Provision of Disk Drives

Whether because of the need to exercise economy or because of a deliberate planning approach, the threshold package had problems in relation to the provision of disk drives. The majority of subject programs were in 5.25" floppy diskettes. The new Phase II schools were provided with only three 5.25" disk drives. Thus, a teacher wishing to use the computers with a class had available a maximum of three computers. This limitation was made more severe by two other factors. First, for some of the software two disk drives connected to one computer were needed. For example, in the case of **Poptran** (a program on demography), a data diskette needed to be run simultaneously with a second diskette containing the program files. Second, in some cases, once the program diskette had been inserted into a drive, it needed to be kept there while the program was running; thus, one copy of a program could not simultaneously be used with more than one computer. If in a lesson a teacher planned to use two or three computers to run such a program, two or three copies were essential. Because of copyright restrictions, in some cases copies could not be produced. In any case, according to Finkel (1985) copyright law precludes the loading of a disk onto more than one machine at the same time, unless the licence specifically permits this.

Limitations of the Project Library

As pointed out in Part 1, a proportion of donor funds was devoted to building the project's central library of software and other educational materials. The idea of a central library had both economic and professional merit. Since the computer innovation was in part an experiment in a new area, it appeared uneconomic to provide the schools with copies of all the software and other materials acquired by the project. It was thought that a project library should provide a central point at which software could be acquired, reviewed and if found desirable, disseminated to the schools. However, it was observed that a central library had a major disadvantage. Since the schools were following centrally mandated syllabuses, it was likely that in a given subject teachers from different schools would wish to borrow the same sort of subject software at a particular period. Thus, if only one copy of a program had been acquired, only one school's request could be satisfied at the right time. The problem was compounded by the fact that some programs had copyright protection and therefore copies could not be made.

There is evidence that, because of the foregoing problems of operating a central library, some schools and teachers viewed the innovation as being inadequately provided for at the school level. There were complaints that software was not being forwarded to schools as soon as it had been ordered for. Some teachers interpreted such delays as an outcome of the fact that for some of the programs the project could not afford to purchase more than one copy. The project schools located in Mombasa repeatedly demanded that the project should establish a software library in the town, the argument being that such a development would place them at par with the schools in Nairobi which were close to the project library. The fact that the request was not acceded to was most likely

seen by the schools as a further indication that the project was under-funded. Some schools reacted to perceived under-funding by making "illegal" copies of programs and manuals borrowed from the project library.

Shortcomings of the Computer as an Educational Technology

Data in the CEPAK study confirmed findings common in the literature that to date computer technology has not developed to a point where it could match, let alone replace, print material as the core of educational processes (McClintock 1986, Roszak 1986 and Goodspeed 1988). Review of a sample of 43 CAL programs in CEPAK indicated that, in order to be able to effectively use the software in teaching and learning, teachers needed to invest much more time than would be the case with regard to textbook-based lessons. It took about 35 hours to work through the 43 programs. About 50% of the time was spent on going through the printed documentation in order to trace operational commands and search for solutions to hitches which occurred in running the programs. Although many of the programs are fairly simple to operate, some leave the novice user virtually stranded at the beginning and immediately force him to go back to the manuals. Some of the manuals are not written such that the novice user has clear operational instructions at the beginning of the program, while many screen instructions assume that the user has studied and understood the manual. For instance, screen instructions may say nothing about keeping CAPS LOCK down, so a teacher spends some frustrating minutes entering responses in lower case, only to be forced to discover from the manual that this approach is technically unacceptable. Or a user may not realise that his 2x should be entered as 2*x in a program which had previously accepted 2x. A teacher who is not used to American english may take sometime to figure out why he cannot proceed when the computer is waiting for SULFUR instead of SULPHUR. Further, the teacher must master the intellectual content of manuals and, in planning his lesson, think of how to reconcile the material with the content and approaches in the students textbooks. Given a situation where only one, or at most three computers will be available for his class of 40+, the teacher has to decide whether to use the program with the whole class or with groups of students. He has to decide on (a) the activities the students will engage in at the computers (b) the activities to be undertaken by students not at the computers (c) composition of groups. He also must design follow-up activities. All this is much more costly in terms of time than preparation for the traditional lecturing, note-giving or question and answer lesson.

Poor Keyboard Skills

The ability to select desired characters on the computer keyboard is an essential first step for any one who wishes to work with the technology. The computer keyboard to a large extent resembles the typewriter keyboard. Thus, familiarity with ordinary typing would constitute a favourable entry characteristic for an individual beginning

to work with a computer. Two students illustrated this point as follows:

> Pauline - Form 4 in S - 10.10.87
> She likes operating the computer as she does typing and thus has an advantage.
>
> Tasneem - Form 2 in U - 2.8.88
> She said, "I think the computers are easier for girls. You see some girls have done typing. Because they are so slow themselves, the boys prefer to have girls on the keyboard. If the boys are on the keyboard they are slow because they take time looking for letters."

In May 1988, after observing a workshop session on wordprocessing, a researcher reported as follows:

> A group consisting of Mrs Sood and Mrs Walji worked much faster than all the other five. This situation, to a large extent, reflected the fact that both ladies appeared to have had considerable experience of the typewriter keyboard.

In Kenya typing skills are not taught to all students as part of the formal curricula, and as a consequence the great majority of students and teachers in CEPAK came into the project without any knowledge of the ordinary typewriter keyboard. This disability constituted a major inhibiting factor in the development of computer operating skills. The following extracts from researchers' field reports are illustrative:

> Observation of Computer Club Activities in R - 16.3.87
> The use of a single finger for ALL characters on the keyboard was the order of the day. In one group, two girls were observed operating the micro simultaneously, with one of them doing most of the typing while the other "specialised" in pressing RETURN at the appropriate time.
>
> Martin - Form 1 in T - 29.6.87
> Martin said he had learnt typing since he had joined the computer club, although he still had problems finding letters on the keyboard.
>
> Sabiha - Form 2 in R - 9.10.87
> Has worked with the wordprocessor and database. Her typing is very poor as she only uses one finger.
>
> Daudi - Form 5 in P - 15.10.87
> Typing fast and remembering commands to do different things are his biggest problems.
>
> English Teacher at R - 18.3.87
> Her major handicap appeared to be lack of familiarity with the keyboard, combined with fear that she might damage the machine or make a ghastly mistake.

Geography Teacher at P - 6.7.87
He did not seem to know much about the computer and typing was painfully slow. He did not know anything about saving his work, nor did he know anything about the basic editing keys. The test paper as it appeared on the screen looked terrible: there were no spaces between questions, no indentations on the left margin and there were many mispellings and punctuation was poor.

Geography Teacher at R - 6.10.87
In using the wordprocessor she had problems with the margins. She feels that she should leave the typing to someone whose speed is faster.

Economics Teacher at R - 6.10.87
In previewing the economics program he was rather slow in reading the screen instructions and in finding characters on the keyboard.

One of the outcomes of poor keyboard skills was that many teachers who did not have the time or persistence to learn the technicalities of operating the computer decided to opt out of the innovation. After a week of observations at school P, a researcher reported:

Observations at P - July 1987
In this school the whole issue of poor typing skills seems to be one of the greatest constraints in using the micros. People who are used to wordprocessing reports as a matter of course may underestimate the effort required of the ordinary teacher to do his work on the wordprocessor. We may have over-valued the contribution of the computers to the administration of the school and as a backup tool for the teacher. Teachers here seem to find it much easier to do their work on handwritten stencils.

The researcher substantiated his general remarks with specific examples, such as the following:

Biology Teacher at P - 8.7.87
He says that he does not use the computers much for notes because his typing is poor. He had tried the wordprocessor for typing in schemes of work but had found that he was so slow that he reverted to handwritten stencils.

A researcher who tried to assist a teacher with wordprocessing had the following reception:

Mr Ramwe - Chemistry at O - 10.2.88
We created a wordprocessing file of several chemistry questions - the beginning of a bank. Mr Ramwe keyed into **Print Options** because he wanted to know how to write chemical symbols, reactions and formulae, all of which have superscripts and subscripts. For instance, he wanted to write the symbolic

formula for Sulphuric Acid - H_2SO_4 - a procedure which takes a few seconds at most. It took him 4 minutes. After he had written two other formulae, namely SO_2, $Ba^2(aq) + CO_3^{2-} = Baco_3(s)$, he paused and asked, "How am I doing?" When I told him: "Wonderful!", he laughed and retorted, "This is a joke!" Asked why he felt so, he took a pen and a piece of paper, and said: "Look here. If I write this formula with my pen, see? I have already finished! But this computer, this wordprocessing, writing the same formula, let's see, let's count the twists and turns in this long one." He counted the keyboard moves in the stoichiometry chemical reaction and triumphantly said, "55 keys! If you have a whole exercise of this sort to type, you will sleep in here! This wordprocessing is not very useful for my subject where you have formulae and chemical reactions. I want another program that you can tell to write these things in a simpler way."

Mr Ramwe said jokingly that he was particularly "annoyed" when he has to hold two keys at the same time, adding, "I don't like this key (the SHIFT)." At the end of the session he had entered 14 questions most of them consisting of 2 or 3 lines. He now became worried because the text he had typed in showed the superscripts and subscripts as carets. He said,"This (pointing at the carets on the screen) will not make sense to the students. I will then have to dictate to them what numbers should be where. After all that trouble, it is not worthwhile to use the options for these formulae." I then explained that when printed, the document would have the superscripts and subscripts appearing in their proper place. He looked very skeptical.

Limited knowledge of the technical operations of the computer not only frustrated teachers' efforts to use the technology to improve performance of their job, but also in some cases increased the monetary costs of the innovation. On a number of occasions damage to the hardware arising from inexperienced handling was reported. Further, cases of damage to stationery surfaced, particularly in relation to using computer printers to cut stencils. An extreme case was observed at school S as follows:

Physics Teacher at S on 10.6.88

He came into the RC to cut a stencil of a maths test for Form 2. He seemed to have quite bit of trouble retrieving his file. After about ten minutes he got his file and loaded the stencil and began printing. The printing stopped after about half a minute and he started again on another stencil. He then found that the test would not fit on one stencil because of the inordinate amount of space he had left between questions, so he went off to get another stencil... After attempting to print two more stencils he said, "I will have to start again" and went off to get more stencils. When he came back, before he had inserted the stencil, he pressed the **SELECT** button on the printer and it then went on printing from memory. After

printing 5 stencils incorrectly, he went off and came back with two more stencils and started all over again. On this next attempt the printer again ran for about half a minute and then stopped. With much audible sighing, he took out the disk, re-booted it and then started again. He ended up with two more stencils cut, but judging by the resigned way in which he switched off the machine, I don't think the effort was any more successful than the earlier ones.

Poor keyboard skills were also observed to be a major inhibiting factor in the conduct of project workshops. It was noted that many hands-on sessions were slowed down because participants had little dexterity on the computer keyboard. In May 1988, a research made the following observations on a workshop session dealing with wordprocessing:

> ...five groups were observed to be extremely slow. Most participants were not familiar with the keyboard. Most took an awkward sitting posture in relation to the keyboard (either seated at angle with crossed legs or seated too far) and took too long to find the characters they needed to compose words. Incidents of single-finger typing were more the rule than the exception. In two of the groups, I noted that at least two people operated the keyboard simultaneously, while in the other three the operator relied on dictation and identification of characters by the other members of the group. At one stage, I was unable to bear the agony of witnessing misconstrued management of the keyboard. I suggested to a group of two that they should operate the keyboard alternatively so that, among other things, each should learn to take the correct posture and to use both hands. The two disagreed with me, arguing that since they were required to learn WP together they should operate the keyboard simultaneously!

The mastery of the keyboard and other technical operating skills was not a problem confined to the earlier period of the innovation. As some teachers became familiar with the computer, especially in the use of applications programs such as the wordprocessor, they soon became frustrated with the time-consuming nature of the mechanics of getting things done using these programs. They were often mystified when, in spite of apparently having followed either taught procedures or those gleaned from the manuals, the machines refused to "obey orders." In the final year of Phase II several users expressed the view that they were still ignorant of many of the "little tricks" necessary for full functional use of the technology. The SMC at school P expressed this view as follows:

> <u>SMC at P on 28.3.88</u>
> It's not easy to learn the database and spreadsheet, or even the wordprocessor. In the wordprocessor I am still having problems with margins and indenting. I know it's supposed to be easy to get from the spreadsheet to the database, but I can't do it on my own. It's easy doing it with (the PD), but I can't

do it on my own. There is nothing in the manual on this.

In a field report, a researcher summed up the same issue a follows:

> After Observations at S - 10.6.88
> There are many basic ideas on the operation of simple packages, such as the wordprocessor, which have not been grasped by the teachers and which nobody has taken the trouble to point out. Use of manuals seems to be minimal, not necessarily due to laziness on the part of the teachers, but because many teachers do not know enough about computers to use the manuals efficiently and sometimes due to lack of clarity in the manuals themselves.

TEACHER ATTITUDES TOWARDS THE TECHNOLOGY

In a number of interviews with school staff, the view was expressed that some teachers were reluctant to adopt the innovation because they considered that it could not financially be sustained beyond donor funding. For some, this view was a convenient excuse for teachers who were either frightened of the technology or did not wish to invest their time and mental energies into the mastery of the new technology and the development of new pedagogical perceptions and practices. However, given a setting characterised by constraints in the financing of education, it was most likely the case that some teachers genuinely believed that the computer was too expensive for ordinary Kenya schools. If, as explained in later sections, a teacher was already convinced that he or she was being underpaid, or that the school system was unable to meet the costs of ordinary teaching and learning materials, it was not unreasonable for the teacher to conclude that the computer was a new fad, perhaps even a foreign one, whose adoption could not but exacerbate the general scarcity in the provision for education.

The belief that the technology was too expensive for Kenyan schools was strengthened by measures taken in connection with the security of the equipment. Given the possibilities of theft and vandalism through burglary, a decision was made to burglar-proof the RCs and insure the equipment. Further, to minimise chances of damage to the equipment and/or personal accidents among users, it was decided that certain technical operations would be confined to the project staff and SMCs. During workshops, care of the hardware and software (including ways of preventing erasure of data through exposure of disks to the elements and accidental formatting) were given due emphasis. However, these necessary measures had the side effect of enhancing anxiety over the technology among school staff.

Burglar-proofing of the RCs would seem to have been regarded by some school staff as confirmation that the equipment was expensive and fragile. Thus, it was necessary not only to secure it against theft and vandalism, but also against unauthorised use. The fact that the hardware was insured was further confirmation. The arrangement whereby only the

SMCs undertook simple maintenance tasks and technical handling - such as making connections between the computer's central processing unit and monitors, printers and disk drives - would seem to have been interpreted by teachers in two ways. First, because the equipment was presumed to be fragile and complicated, the ordinary teacher was not expected to master technical handling. Further, teachers who ventured into technical handling could personally be held responsible for any damage to the equipment. Second, because electric power was the source of energy for the hardware, inexperienced technical handlers risked injury or even death through accidental electric shocks. Incidents of loss of data through corruption of disks or malfunctioning of hardware not only seemed to confirm the fragile nature of the technology but also enhanced anxiety among new users.

The foregoing perceptions of the technology were manifest in the notices displayed in most of the RCs. The following examples are illustrative:

> School R: RC Notice Observed on 16 March 1987
>
> Handle the software with care. It should remain in its cover when it is not in the disk drive.
>
> Bring only writing materials to the room. No handbags, briefcases, etc.
>
> No unauthorised person(s) is allowed in the room.
>
> No students should be in the room without being accompanied by a teacher.
>
> School P: RC Notice Observed on 6 July 1987
>
> Please do not move the computers. Leave them where they are.
>
> Please remember to save your work every ten minutes to avoid losing everything if power fails.
>
> School O: RC Notice Observed on 4 October 1987
>
> CAUTION: BEFORE DISCONNECTING OR CONNECTING DISK DRIVES AND OTHER DEVICES, SWITCH OFF THE COMPUTER. (This was accompanied by a computer diagram of a human skeleton).
>
> Connections on the Apple IIe: Do not touch if you don't understand. For Co-ordinators use only. Make sure the computer is switched OFF before attempting to connect or disconnect ANY cables. Do not mis-match the two types of drives and the controllers.

In a number of interviews school staff expressed their distrust of the technology and fear of causing damage to the hardware. The following extracts from interview reports are illustrative:

Librarian in School R - October 1987
She is quite excited by the micros and finds them "very interesting and easy to learn." But she is afraid of breaking something and being held accountable.

Ms Price: Biology - School Q - October 1987 said that machines were breaking down so frequently that teachers were becoming frightened of using them.

Ms Coda: Chemistry - School Q - October 1987
In a sneering tone she said, "(PD) says play with the computer. But how do you play with it, it might not be working. I am not going to touch these machines until someone teaches me the basic technical aspects." She described these aspects as (a) how to connect disc drives to the central processing unit (b) what facecards work where and how to differentiate face cards and how to fix them (c) what to check before one starts the machine and how to ascertain that all plugs, facecards and controller cards are in their correct slots and condition. She continued,"These are things that have to be shown to each user of the computer and then have each user practice how to carry them out to perfection."

On a more positive note, a number of teachers expressed the wish to have more knowledge of the technical operation of the computers. In May 1987 an SMC at school S stated that teachers in the school wanted to learn more on the technical side of the technology. She explained as follows:

> Only the PD or his assistants are allowed to unplug any part of the machines. This means that we cannot move the computers from one place to another. We do not know how to change ribbons, how to insert new facecards or to fit and unplug the different disc drives. We want to get more proficient in trouble shooting some of the more frequent but minor problems.

There is evidence that lack of knowledge of the technical aspects of the computer limited teachers' access to the innovation and in some cases, converted teachers into helpless victims of their more technically minded SMCs. After observing a chemistry teacher at school S struggling but failing to save a computer file, a researcher stated:

> I wondered just how many people have been turned off using the computers as a result of spending an hour typing in some material and then finding that they could not save their work. A teacher who spends an hour alone in the RC and cannot save his file is very unlikely to go looking for the SMC. The teacher is most likely going to switch off the machine and vow never to touch a computer again. I know for sure that Mr Lafira was extremely frustrated when he could not save his file, muttering under his breath, "These computers can really make you mad!"

In October 1987, after an interview with a physics/ mathematics teacher at school Q a researcher reported as follows:

> Mr Murimi said, "As far as I am concerned, as long a teacher knows how to switch on and off the computer, to slot in disks into the drives correctly and to read and respond to the various directives that appear on the screen, then the teacher can use the computer...I believe that I know how to use the computer quite well, and yet I have never changed a facecard or plugged in disk drives or printers to the CPU." He concluded by saying that whenever he goes to the RC and finds one of these peripherals disconnected he just doesn't use the computer, adding that it was rare to find all four computers unusable.

Mr Murimi's approach probably worked quite well so long as there was a working computer on which a teacher could do individual work. However, serious problems could arise when the technology was being used in a lesson. If during a lesson a peripheral was accidentally disconnected, disruption would occur because the teacher would have to look for the SMC to rectify the fault.

Use of computers in formal lessons reinforced fear and distrust of technology among some teachers. During a lesson, a breakdown of the equipment or the teachers' inability to perform some simple computer operation, was likely to result in loss of face in front of the students. In March 1987, six months after the launching of Phase II, a number of teachers expressed their fear of using the technology in lessons. An economics/geography teacher at school Q said that, apart from bringing in a class to show them the basics and a few elementary ideas on the wordprocessor, he had not used the computers in formal lessons. He felt that he was "still too raw to try it in economics or geography lessons. I do not want to risk seeming inexpert in front of students." A biology teacher at school T addressed the issue as follows:

> There is worry that teachers who have to take classes in the RC have not had enough experience in operating the machines. These teachers fear loss of face in front of students when something goes wrong and they do not know what to do.

Reporting on a lesson (July 1987) in which a physics teacher in school U was observed struggling with a computer in front of a class, a researcher stated:

> The teacher then tried to run the simulation but it would not work. He went back to the main menu, but again it would not work. Then a lot of talking and chattering started as the teacher struggled with the keyboard, but nothing happened. He went back again to the main menu, but still nothing. I can appreciate teachers' unwillingness to use the computer if it makes them look foolish in front of their classes. If for any reason students do not like you, they can be particularly unmerciful in situations such as this.

TIME AS A VARIABLE IN TEACHERS' USE OF THE TECHNOLOGY

Teachers in the project were being required not only to develop operational familiarity with the computer, but also to transfer their experiences to the development of new pedagogical perceptions and practices. For instance, with regard to CAL programs teachers were required to learn how to run a given program, as well as to think of where, when and how the program could be used to enhance student learning. Time was an important factor in this process.

Throughout Phase II, lack of time was repeatedly cited by teachers as a major factor which constrained adoption of the computer innovation. As per Table 4.01, lack of time was the most frequently cited reason for teachers' reluctance to use the computer to produce teaching and learning materials. In the 1988 survey, 53% of the teacher sample (60% in the pilot school and 51% in the new schools) strongly agreed with the statement that "mastery of the computers requires time which I have been unable to find in my daily schedule of duties."

Some of the teachers directly related lack of time to the complexity involved in mastering the technical operations of the computer. In October 1987, a geography teacher (school R) who was an enthusiastic user of the computers stated:

> Using the computers is too time-consuming. Too much time is needed to read the manuals.

A history and an English teacher who had attended the start- up workshops in August 1986 but subsequently failed to develop interest in using the computers, argued as follows:

> Mrs Nduluku - History - School S - September 1987
> There is too much to be learnt about the computers before they can be useful to you. Whatever you do on the computer is too slow and time-consuming.
>
> Ms Ngimwa - English - School R - October 1987
> Practice on the computer requires time so that you can concentrate, but time is never there. It's no use trying to learn the computer during isolated free periods, as by the time you get back to the micro you will have forgotten what you had learnt.

Perceptions of the Innovation in Relation to Syllabus Coverage

In a number of cases, time constraints together with the inappropriateness of software were cited as a reason for not using the technology. The following three examples illustrate the point.

> **Head School U - in June 1987**
> The main reasons are lack of relevant software in some subject areas, fear of losing teaching time, and basic lack of

using the computers by themselves.

SMC at School S - May 1987
There is a shortage of software suitable for Forms 1 and 2, and this has prevented teachers from using the micros. Teachers are very selective in what programs they use with students. Teachers are not prepared to waste time with programs which do not fit in with the way they are teaching.

Head of English at School T - in June 1987
If someone will give me some software which when I use it with students, it will not make me feel that I have wasted time, then I will go to the RC.

The view that "too much time" should not be spent on the technology because of its limitations as a teaching-learning tool, was a pointer to a widespread perception that the current curriculum had in-built time constraints which did not favour pedagogical experimentation in new directions. Most teachers who expressed views on the issue associated lack of time for mastery and use of the computers with constraints in the schools' implementation of the formal curriculum. The following views of ordinary subject teachers were representative:

Mrs Ndithe - Biology - School T - in March 1987
The classes which go to the RC for biology will lose a theory period and will thus fall behind the other classes.

Mr Ramwe - Chemistry - School Q - March 1987
It is not possible to cover the syllabus in the time available if one wants to give the proper practical slant to chemistry. There is intense pressure in the school to finish syllabuses. The pressure comes from the headmaster who wants frequent progress reports on how much of the syllabus has been covered. This is one of the greatest constraints against use of the computers.

Mr Bokiwe - Math - School P - in July 1987
There is too much examination pressure to allow for time to use the computers.

Mrs Ndoju - English - School P - in October 1987
There is no time and there is too much exam pressure. The teachers don't believe that the computers will help with preparing students for public examinations. The teachers fear that they could be reprimanded for wasting time on the computers.

There was evidence that the perceptions and fears of ordinary teachers were shared by the schools' senior management. The following statements from a head, a deputy head and a dean of studies were representative of the views of senior management on the time issue.

Head of School S - in May 1987
I don't wish to make use of the computers compulsory, since many teachers have problems in covering the syllabuses in their respective subjects, especially with the 8-4-4 syllabuses for Form 1 and 2. I don't want to challenge teachers later in the year as to why they had not covered syllabuses only to be told that they had wasted time with computers.

Deputy Head School P - March 1988
Teachers don't want to change their ways. Teachers also don't know enough about the computers and don't realise that they can do something more efficiently with the computers. If they did they would use them. But they don't have the time to go there and learn about them. I myself don't have the time.

Dean of Studies School P - July 1987
The computers should not be used for teaching students in class. They should be seen as a back-up tool for the teacher. Time in class is precious and should not be wasted on computers.

Given a climate in which the schools were placing most emphasis on coverage of the formal curriculum, in a sense, teachers who chose to use the computers for formal teaching risked the accusation (albeit unspoken) that they were deviating too much from acceptable performance of their official job. Teachers perceived to be guilty of such deviation could, without overt indictment, suffer impairment in their career progression. Such teachers would be particularly vulnerable if, for reasons that had nothing to do with use of the computers in lessons, their classes performed poorly in the public examination.

Teacher Use of Time During Official Hours

The opportunity costs incurred by teacher users of the computers were studied from the standpoint of teachers' utilisation of time. Data collected from the 1988 survey was analysed with a view to estimating the length of time teachers spent on official duties and the frequency of teacher use of the computers during specified periods. The results of the analyses are presented below.

For all six schools the average weekly teaching load was 20.74 periods (standard deviation - 6.49).[1] Given that a period was 40 minutes long, during each week on average a teacher spent 13.83 hours conducting lessons. The average number of hours teachers claimed to be spending on preparation of lessons, marking and carrying out other schools duties are shown in Table 4.02.

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1. The teaching loads were not markedly different from those reported in the baseline study. As per Table 2.03, the pre-Phase II average teaching load was 19.3 periods (standard deviation - 6.36).

Table 4.02. Hours per Week Spent by Teachers on School Activities Outside the Classroom.

Activity	Mean Number of Hours	Standard Deviation
Preparation	9.75	7.03
Marking	9.13	8.57
Other Duties	7.79	11.02

If the 13.83 hours spent by a teacher on conducting lessons are aggregated with the mean number of hours in Table 4.02, it would appear that in a week teachers were on average spending 40.5 hours on school work.[2] An attempt was made to relate this official week with the teachers' responses on times when they claimed to have been working with the computers. Table 4.03 shows the percentages of teachers who indicated that they worked with the computers during specified periods of the week.

The data in Table 4.03 show two trends. First, overall only about a fifth of the respondents were prepared to risk use of the technology in the actual conduct of lessons. Second, with regard to use of the technology outside lessons, in all six schools most teachers preferred to work with the computers during free periods. In other words, most teachers claimed that they could only work with the technology during the same times of the school day when they were also engaged in preparing lessons, marking and undertaking other school duties (Table 4.02). By way of extrapolation, unless preparation and marking was done outside the official day or these activities, together with other school duties, involved substantial use of the computers, one could conclude that the innovation was requiring teachers to reduce the official time previously spent on school work. What was the reality?

Table 4.03. Teachers Working With Computers During Specified Periods.

	Percentages of Respondents						
	P	Q	R	S	T	U	Average
Free periods	59	77	61	75	47	84	67
Lessons	18	23	17	8	7	40	21
Lunch break	18	23	9	17	13	40	21
Evenings	41	8	13	33	0	20	20
Weekends	36	15	13	25	0	4	16

2. The official working week in the Kenya civil service is 40 hours.

Observations and interviews of teachers revealed that, apart from teachers in the two boarding schools, only a small proportion of teachers undertook school work after official hours. For the majority of teachers who lived away from the school compounds, all preparation of lessons and correction of students' written work was done in school during the official day.

Not content to rely on the written survey data analysed in Table 4.02, the research team used observations in lessons and staffrooms, and discussions with teachers to estimate the actual time taken in preparing lessons and in marking.

In relation to marking, in interviews (at schools P, Q, R, S and T) 8 teachers (6 of science) gave estimates ranging from 2 to 5 hours per week; 4 language and mathematics teachers claimed that they took much longer. The teachers' claims were counter-checked through observations in the staffrooms and scrutiny of students' assignment books. On the whole, it seemed that a lot of marking was done within lessons and that, in most subjects, only fortnightly or monthly tests were marked during the teachers' free periods. It would appear that the claim by teachers in the written survey (Table 4.02) that 9.13 hours on average were spent on marking was an exaggeration. The difference between the average claimed and the actual time spent on marking could have been devoted to work on the computer.

Observations in the staffrooms revealed that what most science and humanities teachers referred to as lesson preparation consisted mainly in the compilation of notes for students from textbooks. This observation was confirmed in interviews with a number of teachers. A physics teacher at school R, who said he spent 2 periods per day preparing lessons, claimed that he took 3 - 4 periods of each day to read books and compile notes. The dean of studies at school P said that "notes writing accounts for 90% of the teachers free periods." The claim by teachers that compilation of notes had increased with the introduction of the 8-4-4 curriculum, "because in most subjects there are no comprehensive textbooks," did not seem to be a satisfactory explanation: upper school teachers were observed to be as pre-occupied with transcribing notes from several books just as much as their counter-parts in the lower school 8-4-4 classes. This finding seems to be a confirmation of the observation by Woodward (1987) with regard to American teachers that "many teachers are dependent on teachers' guides and textbooks to organize day-to-day instruction."[3] If (as apparently visualised by the teachers) compilation of notes is regarded as part of lesson preparation, the claim in Table 4.02 that 9.75 hours per week were spent on preparation would appear to have been close to the mark. In relation to CEPAK, compilation of notes should have been a tailor-made activity on the computer. Thus, the compilation of notes was not an activity which innately conflicted with learning to work with the technology. The fact that most teachers were

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3. Woodward, A. Textbooks: Less Than Meets the Eye. Journal of Curriculum Development 19.6, p. 51, 1988.

observed compiling notes manually, rather than using the wordprocessor, most likely had to do with negative attitudes to the computer and/or poor operating skills.

With reference to teachers' claims that there is no time to work with the computers during official hours, in March 1988 a researcher recorded the following rebuttal:

> The main reason why lack of time has been quoted by teachers as the biggest factor in their not learning to use computers seems to be that it is the most obvious factor to the teacher in terms of "a reasonable" reason. Several teachers are prepared to admit that they have the time, but they just do not seem to have used it on computers.

Echoing the researcher's views, in October 1987, an English teacher in school T indicated that teachers conceived the computer innovation as requiring them to make sacrifices in relation to another dimension of time. She stated:

> Teachers are dishonest to claim there was no time to go to the RC because most of them spend their time knitting or gossiping, or they ask to go to town to visit friends in offices.

On a number of occasions, it was observed that some of the staffrooms were noisy, with teachers engaged in all manner of discussion of non-professional issues. Further, a number of teachers who at one point in an interview would claim to have no time in which to work on the computers, would at another point claim that teaching is tiresome and that they needed to relax during some of their free periods.

Reporting on a visit to school S in June 1988, a researcher stated:

> At 12.15 p.m. I went to the larger staffroom and found 5 teachers gossiping. Four other teachers were basking in the sun outside.

Referring to an interview with one of the teachers who taught business education, the researcher continued:

> Mrs Rungu was reading a novel. She told me that she normally teaches 17 periods per week, but currently she has only 10 periods because some of her load had been allocated to teacher trainees on teaching practice ...She says that she spends her free periods marking, adding "but now I have locked the (students' exercise) books away and I am reading because we also need to relax, you know. This computer business is too demanding!"

From the foregoing, it would appear that, instead of relaxing in unproductive ways teachers could have used the time to work with the computers. However, it could also be argued that, by opting to use the

computer during some of their free time, teachers who may previously have relaxed in an intellectually productive way - such as reading for pleasure - were incurring an opportunity cost. A number of teachers, particularly at school U, were observed to be captivated by the drawing power of the computer screen. Some of these teachers, rather like the students, were observed spending a considerable amount of time playing computer games. To the extent that this form of relaxation drew teachers away from accumulation of knowledge through consultation of a wide choice of sources, it could be argued that the innovation had the effect of narrowing teacher intellectual growth.

Blind Faith in the Technology

Closely related to the narrowing of teachers' intellectual growth was the observation that, in a number of ways, the innovation had the effect of blurring some teachers' critical judgement of what aspects of technology could sensibly be adopted for teaching and learning. Some teacher users of the new equipment provided through CEPAK seemed to have developed blind faith in technology. In some cases, this faith resulted in both waste of teachers' time and neglect of students' real learning needs. Use of video and overhead projector (OHP) at school U was on occasion observed to be faulty in this sense. Some of the OHP transparencies used in lessons amounted to no more than notes which the students proceeded to copy. The time spent in preparing such transparencies would have been better utilised if the teachers had wordprocessed and reproduced copies of the notes for students. Such an approach would have made more time available for teacher-student interaction during the lesson. In a biology lesson (October 1987), the video was observed being used most inappropriately. The teacher brought a class to the RC to view a video tape on the lion. Unfortunately other groups were already in the room, with some of them making a lot of noise. In spite of the already high level of noise, the biology teacher loaded the video tape and instructed her class "to look and listen carefully." Even more daunting, the students were asked to write notes as they viewed the video running at normal speed. Use of the computer as an electronic chalkboard often displayed blind faith in the technology. As discussed in Part 3, some teachers were observed taking time to copy on the chalkboard what students were already viewing on the screen. Also discussed in Part 3 were lessons in which the wordprocessor and spreadsheet were used seemingly not because their use enhanced student learning, but because the teachers were sold to the allure of the technology.

Unnecessary waste of time associated with blind faith in the technology was to an extent illustrated by teachers' efforts at programming. During the start-up and subsequent workshops, computer programming was discussed as a tool which teachers could use to develop educational software in their subjects. Each school was provided with basic programs and manuals in two languages, PILOT and INSTANT PASCAL. Encouraged by seemingly successful efforts during the pilot phase and lack of software which is suitable for the Kenya curriculum, a few teachers attempted to learn programming in the two languages. The example of the SMC at school R is illustrative. In March 1987 he said that after the initial workshop, he

had spent most his free time over three months to learn how to programme in PILOT. At the end of the three months he was only able to produce 25 multiple choice questions in physics. Observation of similar efforts at schools P and T indicated much less success. Although it could be argued that in the long run teacher mastery of programming could be useful, use of PILOT to produce multiple choice tests probably amounted to a misapplication of the technology. Teachers would have done much better to learn wordprocessing and then produced copies of the tests for students to answer on paper. Alternatively, teachers could have been introduced to simple test-generating software. The time saved by avoiding the detailed technicalities of PILOT[4] could have been spent in developing the professional quality of the tests.

Constraints in Working With the Technology During Unofficial Hours

According to the data in Table 4.03, significantly higher proportions of teachers in schools P and S worked with computers during evenings and weekends. This difference is most likely explained by the fact that P and S were boarding institutions while the other four were day. It would appear that, because most staff in P and S lived in the school compounds and thus did not have to travel between home and school everyday, teachers in the two schools had more time to work with the computers than was the case for their colleagues in the other four schools.

If teachers in the day schools wished to work with computers in the evenings of schools days, they risked travelling home after sunset. This was no small sacrifice given the vagaries of weather, the hassle of having to travel by overcrowded public means and the possibility of encountering undesirables in the street. If day school teachers wished to work with the computers during weekends, they had to sacrifice not only the time taken in travelling to and from school, but also the financial cost of the journeys. Given pressure on public transport and constraints in the availability of rented accommodation suited to the house allowance paid to teachers in Kenya, some teachers claimed that they spent a considerable amount of time travelling. An extreme case was an agriculture teacher at School T. He said that he lived 40 km away from the school. He left his house at 6.30 a.m., changed buses three times and if he was lucky with the transport, arrived at school just before 8.00. Thus, every day he spent a minimum of 3 hours travelling between home and school. Most teachers who lived away from school indicated that it was too expensive for them to return to school to work on the computers during weekends.

A major opportunity cost incurred by teachers related to the fact that the innovation required teachers to re-organise their life styles in order to fit in weekend and vacation project workshops and individual work on the computers at school. There is evidence that this cost, which

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4. In order for one to master PILOT, one must be conversant with three manuals as follows: User's Guide - 50 pp.; Editor's Manual - 180 pp.; Language Reference Manual - 316 pp.

had both a social and a financial dimension, was recognised and to a considerable extent resented by some teachers.

The innovation required teachers to reduce the time previously devoted t family and social life. Teachers, like other members of society, have family responsibilities (such as looking after children and house keeping) and social commitments (such as participation in welfare activities, hobbies and religious worship). In all six schools many teachers, particularly married women[5], cited family and social commitments as reasons for their being unhappy with computer activities organised during evenings, weekends and school vacations. In October 1986, soon after the launching of Phase II, the head of school R addressed herself to the issue as follows:

> The issue of when teachers could work on the computers needs thought: single free periods are inadequate because they do not give a sufficiently long period for practice. Practice after school and during weekends is in competition with house keeping chores for the majority of teachers.

In March 1988, during the final year of Phase II, an economics/geography teacher at school Q expressed himself in a similar vein:

> Don't underestimate the time it takes to learn to operate these computers. You rush into the RC for one period and just as you are getting something, you have to go off and teach. There is no time! Sometimes I feel I am neglecting my family with taking work home.

The conflict between the innovation and teachers' family responsibilities came to the attention of the implementation team. With reference to school S, the PD's quarterly report for July to September 1987 stated:

> There appears to be a considerable load on the computers during the evenings and weekends, <u>with some husbands becoming quite concerned</u>. (Underline added)

The tension the innovation created in some families was illustrated in two interviews with Mr Thumbi, a male teacher user of the technology. His wife was a teacher in a neighbouring project school and was also interested in mastering use of the technology. Reporting on an interview with Mr Thumbi in October 1987, a researcher stated:

> Mr Thumbi has sacrificed a lot of his time in order to master the technology. He estimated that between September 1986 and September 1987 he had spent 1000 hours (11.41% of all hours in a year) on the computer. He said that he had given up his lunch hour, half-days off and the time he used to spend doing his

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5. According to the baseline and 1988 surveys, 62% of the teaching staff in the project schools were female.

domestic duties, such as helping with the children and running errands such as paying bills. He had also given up his recreation time during weekends. He said that with 27 periods of teaching per week, there was little time to work with the computers during school hours.

In August 1989 another researcher interviewed Mr Thumbi. The teacher said that he was still spending most of his evenings and weekends working with the computers in school, adding "but my wife can't do that because she has to do the house keeping. She is now demanding that I buy a home computer so that, in between family chores, she could have a chance to work with the technology."

The computer innovation required teachers to forego income from activities undertaken during the teachers' free time. With reference to the problems of financing education in Sub-Saharan Africa, Williams (1986) points out that "economic constraints...have bitten deeply into the real value of salaries of teachers...They are tempted to engage in other economic activities to supplement their income, 'moonlighting' by doing unauthorised supplementary work and - in urban areas particularly - drawing an increasing share of their income from private coaching."[6] In discussing the remuneration of secondary school teachers in Kenya, Makau (1987) presents evidence that, relative to other employees in the public sector, teachers were underpaid. Thus, it is no wonder that some teachers in the project schools were engaged in activities which earned them supplementary income. Referring to the conflict between the innovation and teachers' efforts to earn supplementary income, in June 1988, a business education teacher at school S stated:

> Some of us are very involved in the informal sector and we don't have the time to learn about computers. Some of these things on the computer take a lot of time to learn.

Data was obtained on some of the money-making activities of teachers. A senior member of the staff of School R was rumoured as owning a fleet of taxis and a number of houses for renting. The following extracts from researchers' reports on in-school interviews illustrate teacher income earning activities:

> Mr Ramwe, Chemistry - School O - February 1988
> Time, as Mr Ramwe pointed out, is crucial for he has to do a lot of evening coaching. He told me that he had 5 groups of students to coach and that he needed the money to support his two sisters who are in secondary boarding school. He ruled out evenings and weekends as times for learning to use the computer because that is when he does his shopping. He also has to coach

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6. Williams, P. African Education Under Siege. In Hawes, H. et al. Education Priorities and Aid Responses in Sub-Saharan Africa. Overseas Development Administration and University of London Institute of Education, p. 97, 1986.

his primary school son who seems to have so much maths homework which he does not understand.

Mr Nganda, Kiswahili - School T - March 1988
On Monday to Friday, between 7 p.m. and 10 p.m., he coaches 4 primary school pupils, all relatives. On Saturday - between 9.30 and 11 a.m., and 3 and 5 p.m. - he gives them more coaching.

Mrs Leli - Christian Religious Education - School T - March 1988
Mrs Leli had come to the staffroom to sell a pair of shoes to Mary. Mary tried on the pair but it did not fit. Mrs Leli asked me whether I wanted to buy the pair...Sitting in the staffroom during the lunch break, I observed that Mrs Leli holds quite a "shop": she sells rice, tomatoes, oranges and buns to other teachers...She says that she has a small farm in which she grows bananas, beans, maize and several other vegetables. She goes to work in the farm every Saturday morning.

Mrs Mutei, Biology/Geography - School T March 1988
Three evenings a week she has to manage a bar - usually Wednesdays, Fridays and Saturdays.

Other data suggested that some teachers visualised the innovation as an opportunity to earn extra income and to enhance their employability through formal certification. During the Nairobi start-up workshop in August 1986, there was a near riot because most participants ganged up to demand that the project pays them out of pocket allowances for the days spent in the workshop, and that on its completion they be issued with certificates of participation. Although in subsequent workshops both demands were acceded to, some teachers did not seem to be altogether satisfied. An exchange of letters between the PD and a would-be workshop tutor illustrates the point with regard to allowances. On 10 April 1987, the PD wrote to a mathematics teacher inviting him to be a tutor at a workshop scheduled for 20 and 21 June. In part the PD's letter read as follows:

> I am expecting that this workshop would consider the relationship between the various possibilities of LOGO programming and the 8-4-4 syllabus particularly for the first two years of secondary. In this respect it will be necessary (for you) to consider in detail the 8-4-4 syllabus and its intersection with various LOGO ideas ...Kindly note the pre-seminar timetable which you will need to strictly adhere to:
>
> April 30th - You agree to be leader and lay out your ideas for the seminar;
> May 22nd - You submit your timetable, pre-seminar suggestions and outline ideas for seminar documents and work plan;
> June 12th - You submit to me your complete plan of campaign together with handouts, lists of materials required etc.;
> June 19th - You ensure that all materials are available at the

site;
June 20th and 21st - (You lead) the workshop.

As payment for preparation and leading discussion in the workshop, the teacher was to be paid shillings 1200 (approximately US $67). On 28 April, the teacher replied as follows:

> Apart from other reasons, please excuse me since I do not wish to participate in the 20-21 June 1987 workshop because the payment is not worth my time and effort over the weekend hours. The relatively few hours I get to be with the family after my week's work in school are more precious than your offer of payment over that period.

In relation to formal certification, one of the SMCs at school Q bluntly pointed out that his main reason for taking interest in the technology was that he was already enrolled in a commercial business course; thus mastery of the electronic spreadsheet as an accounting tool would facilitate his acquisition of qualifications which would enable him to leave teaching. In both schools Q and R there were strong feelings that mastery of the computer by teachers should be formally linked to an examination conducted by a relevant and recognised authority. In March 1988 and again in August 1989 the SMC at school R mentioned Pitman Examining Board of the United Kingdom as a suitable authority.

CONSTRAINTS IN THE TEACHER EDUCATION COMPONENT

Use of the Project Director's Time

The time available to the PD was a major determinant of the outcomes of the innovation. The PD had to balance the time available to him such that he covered both the administrative and professional aspects of the project. Originally it had been planned that an assistant to the PD, who was qualified to manage the office, would be hired. In August 1986 an office manager, with teaching qualifications, was taken on, but on acquiring a working knowledge of the computer he began looking for a more lucrative job elsewhere. He left CEPAK in February 1987. Rather than risk taking on a new manager whose stay in the project could not be guaranteed, the PD elected to take over the major management tasks. The rest of the administration was delegated to the technical assistants and the secretary employed to work for the research team. Albeit for a good reason, in deciding to take on more administration, the PD was making a choice to spend less time on the professional implementation than originally planned. The effect of this choice is brought out through discussion of the PD's monthly programme. The following is an extract from a letter, dated 19 October 1988, from the PD to heads of the project schools:

> The PD's Programme for November 1988
> 1st - Visit school T
> 2nd - Visit school S

3rd & 4th - In project office
5th & 6th - Geography workshop in project office
7th & 8th - In project office
9th - Visit school Q
10th - Visit school R
11th - Visit a school not in the study
12th - Mombasa town workshop
13th to 18th - In project office
19th - Nairobi town workshop
20th Sunday - Rest
21st - In project office
22nd & 23rd - Heads workshop in project office
24th to 26th - Production workshop in Mombasa
27th Sunday - Travel back to Nairobi
28th to 30th - Production workshop in Nairobi

Researchers' reports on observations for November 1988 show that the PD spent the time as scheduled. Analysis of the above programme shows that during the month the PD spent his time as follows: (1) 5 days visiting schools. (Note that schools P & U and another school not in study were not visited during the month); (2) 12 days conducting workshops; (3) 11 days in the project office; (4) 1 day for rest; (5) 1 day travelling back to office. The number of days spent in workshops were above the average for most other months in Phase II. However, most of the time saving from reduced workshop schedules would have gone into covering visits to all schools during a month, attending conferences and consultative meetings with the funding agency, and allowing for more time for the PD's relaxation. Thus, during any other Phase II month, the amount of time available for both professional and administrative work in the office was not much higher than was the case in November 1988.

The specific tasks performed by the PD during the one third of a month spent in the project office were important. In an interview with a researcher in February 1988, the PD defined his use of time as follows:

> Apart from planning what is to be done in workshops, attending to correspondence and maintenance, and putting in orders for new materials, there is report writing to be done and I consider that dissemination of what the project is about - through attending conferences - is vital for the project. The evaluation of software in the office is essential. I would have wanted to have looked at the documentation and...tied down CAL to a subject and a specific date in the scheme of work, but there has been no time.

The above statement indicates that, partly because of the earlier decision to take on more administration, the PD made another important choice as to how his time would be spent. Because he considered that the administrative and professional undertakings described in the first part of the statement were more important, he decided to give them time at the expense of the underlined part, that is the review of software and preparation of guidance as to how it could be integrated into teaching

schemes of work. It was observed that during most of Phase II, the review of both CAL and other software, and preparation of guidance notes to schools was largely delegated to the technical assistants. This was illustrated in a discussion between the PD, the head of school S and a researcher. The PD and the researcher had visited school S on the same day in June 1988. Reporting on the discussion the researcher stated:

> At 11.50 a.m. the PD asked, "Any problems?" The head replied, "Oh yes, those **Quick Tests**. I have tried them and could not get anything to work." The PD replied, "Well, it looks as if we will need to spend some time on that program." I remarked that I had also tried the program and had failed to get anything meaningful. I told the PD that I had sought for help from (a technical assistant), but that he had diagnosed the problem as being due to the fact that the disks had write-protect tabs. However, after removing the tabs he was unable to get to the menu...The PD remarked, "Oh! They looked to be straightforward and I asked (the technical assistant) to look at them, and if they were any good, to copy them and send them to the schools. He told me they could work, so he copied them and sent them to schools together with the manual. It looks as if I will have to look at them and see what can be done."

The delegation of software review to the technical assistants had implications for the implementation of the innovation. Since the technical assistants were neither teachers nor educationists, they were not equipped to make meaningful comments on the pedagogical value of programs. They were not in a position to make decisions as to the kind of guidance needed by a teacher in order for him or her to be able to use software effectively. It was observed that the technical assistants made an attempt to prepare documentation on software forwarded to schools. However, scrutiny of this documentation revealed that it consisted largely of material copied verbatim from the printed program manuals.

The fact that software was rarely professionally reviewed reduced the impact of project workshops aimed at promoting the integration of the technology into the curriculum. On one occasion (May 1988) when the PD, in preparation for a workshop, reviewed a program and carefully prepared material to focus workshop activities, it was observed that the participants felt that they were being exposed to a worthwhile experience. Reporting a session dealing with grouping as a useful strategy during lessons, a researcher stated:

> Addressing the participants the PD said, "I want to suggest how you could conduct a lesson to a class of 40+. Let us assume that one of your 4 computers is out of order and therefore you have available only 3. You need to give your computer-assisted lesson much more work at the planning stage than is the case with your normal lessons." (At this stage of the session, the attendance had built up to 46). "I will divide my class into 9 groups. Remember we have 3 computers. I will group by activities. At any one time only 3 groups will be at the

computers. The other 6 groups will be on non- computer activities, but these activities will be closely related to what is being done on the computers. I have chosen the program **Super Factory** as the basis of my lesson. This program deals with the aspect of 3-dimension, which many students find difficult. The first activity of my lesson will be playing with the actual program on the computer: three groups will be on the computers for about 20 minutes. The second activity has been worked out from the manual of **Super Factory**. It is important for you to read the manuals of programs. The groups dealing with the second activity will answer the questions in the worksheet that I am going to give you. Do not write on the handouts because when groups change, the others will need to use the same handout. For the third activity, in which 3 of my groups will be engaged in, I have worked out an exercise in which a metre rule will be used to attempt solutions to 3-dimension problems. All three activities aim at understanding 3-D through rotation."

The participants were then randomly grouped and worksheets handed over to six of the groups. For the next 40 minutes the groups concentrated on their various exercises, with the PD going round to assist.

On the whole the participants seemed to be interested and excited, not least because the PD had carefully planned and focused the activities. Moreover, in spite of a few passengers, the concept of "busy noise" was observed in operation. One felt that if in earlier workshops a similar approach had been adopted a lot more could have been achieved.

Approaches in Teacher Education Workshops

In contrast to the foregoing example, most project training activities were characterised by generalised and unsequenced approaches. There was no evidence that the implementation of the innovation proceeded according to a carefully thought-out plan of action indicating priority areas and sequenced stages of development of expertise and use of the technology. With regard to lack of sequenced development, it was severally observed that, in a given sphere, later workshops to a large extent repeated activities of earlier workshops. Because of this approach, later workshops did not fully take into account the learning needs of either teachers who were new to the innovation, or those who had some knowledge from earlier workshops. A number of teachers noted the tendency for workshops to be repetitive and expressed a wish for more progression in training. In October 1987 a mathematics/physics teachers at School R stated:

> Some people who attended the initial workshop now want different courses and not a repeat of what was done earlier.

On being invited to attend a science workshop in which further review of

software was to be undertaken, in June 1988 a physics teacher at School S complained to a researcher as follows:

> But we have done all this many times before. If it is the same thing again it will be a waste of time. It is alright if it is for new teachers or if we are being asked along to give ideas to new teachers, but not if it is the same thing all over again. What we now need is to be shown how to use the software which we have already identified.

The absence of progression in training was also exemplified by the lack of organised and regular follow-up of workshop proceedings. Several teachers complained that at the school level, there was inadequate follow-up of project workshop proceedings. In september 1987, an SMC at school T addressed the issue as follows:

> There is no communication before or afterwards. I don't think people know what others have done in the workshops.

The foregoing approach to the implementation was in line with the exploration and discovery implementation strategy discussed in Part 2. The PD's decision not to devote much of his time to the review of software would appear to have been partly influenced by the reasoning that teachers in the project schools should be left to undertake the task, and on their own, discover where and how in the curriculum the technology should be used. Following this reasoning, training through workshops and visits to schools were meant to be no more than a spark which ignited in-school dissemination of the ideas of the innovation. Thus, the issues of progression in staff development and follow-up activities after workshops were seen largely as the responsibilities of individual project schools. The PD's views on what he considered to be the schools' responsibilities were implicit in his regular reports on the implementation. For instance, in relation to how computer-assisted lessons should be organised, in reference to school Q the PD's Quarterly Summary for July to September 1988 stated as follows:

> We still believe that the head of the school should reconsider the practicality of taking complete classes to the computer room since at the moment, whenever computer lessons are timetabled, then two members of staff are involved. If a member of staff wishes to take a class to the (RC) at other times he normally has to leave half the class in the (classroom). We have argued before that this is not a satisfactory arrangement and more thought at the senior level should be given to this problem since solutions have been laid out, which only require a small expense.

The choices made as to how the time of the implementation team should be utilised had a number of untoward outcomes which the PD may not have anticipated.

In relation to achieving operational expertise, the discovery approach assumed that teachers would readily sit down alone, go at it, find things out for themselves, be brave enough to experiment and consult the manuals and documentation when necessary. This strategy was translated into practice in project workshops. Experienced users who played the role of tutors did not see the need for making technical operating knowledge explicit for novices. Many tutors at workshops assumed a level of competence in technical operations and knowledge about the basics of operating different programs which the novice simply did not have. The evidence suggests that for some teachers, this approach largely led to disillusion and frustration, waste of time and energy, and a strengthening of belief that using computers was difficult. The following two extracts from field research reports reveal teachers' views on the Phase II start-up workshops:

> SMC at School Q - 17.3.87
> The initial training course was too short and too many things were crammed into the two weeks. Too many topics were covered. I would have preferred to have had more hands-on time on the computers themselves. It would have been better to tell people very specific points about how to operate the computers rather than leaving them to find out many things for themselves after the course was over.
>
> Discussion With a Group of Teachers at P - 26.3.87
> The group felt that teachers need to be given little hints on how to manage the keyboard, how to load and run programs, how to get out of trouble in the more common error situations, and how to do things quickly.

Similar views were expressed after the first subject-specific workshops in May-June 1987. The following two examples were representative:

> Mathematics Teacher at School P - 5.7.87
> The mathematics workshop was very useful. I particularly liked the spreadsheet, but when we came back we could not get the spreadsheet to produce the answers we got during the workshop. We were helped by the accounts clerk and the bursar, but the way they set things up on the spreadsheet was different from what we had been shown during the workshop, but they got a better answer. There are small tricks in using the spreadsheet that we were not told about during the workshop.
>
> Mathematics Teacher at School S - 29.9.87
> She said that she had tried to use the spreadsheet after the mathematics workshop but had problems with the copy function and felt that it was not well explained during the workshop.

The problem of mastery of the technical operations of the computer did not seem to have diminished with time. In the final year of Phase II many observations, such as the following two, were recorded.

Head of School S - 6.6.88

She opened the software cupboard and asked me, "How does this **Newsroom** thing work?" She took out the disks and loaded them onto one micro and got the main menu on the screen. She remarked, "That is as far as I can get." She was unaware of the use of the arrow keys to highlight the menu option desired, or the use of the **Open Apple** key to select from the menu. She also did not know that one needs a formatted data disk to be able to use the program. I showed her and she said "Oh! Now I can begin to try this for myself."

Observations at a Workshop in May 1988

Throughout the workshop it was obvious that the computer still terrifies or mystifies the majority of teachers in the project. There is thus need to approach workshop sessions in a carefully sequenced manner, such that the tutor does not make too many assumptions: he should start from where the learner is and must try to ensure that in the course of learning a particular aspect, some learners are not lost by the wayside.

In relation to training teachers on how to integrate the technology into the curriculum, the problem of unfocused and unsequenced workshops loomed large. A dominant mode of the generalised approach was the tendency for workshop tutors to talk about how programs could be used in lessons, rather than actually loading a program and demonstrating its use. Commenting on the October 1988 workshop for science teachers, a researcher reported:

> None of these sessions were particularly illuminating in terms of helping a teacher to find out just what he should be doing during a computer session with his class. They were not demonstration sessions, but sessions which gave the presenter a chance to talk about the program.

The futility of talking about programs rather than demonstrating their use was illustrated at a workshop for mathematics teachers in September 1988. In introducing new programs, the PD held a number of disks up in the air one by one, making comments as follows:

> **Perplexing Puzzles:** This would be difficult to fit into any syllabus, but it would be good for playing around with after school if kids are getting too much of formal maths.
>
> **Algebra Word Problems:** This is about how to turn English into mathematics.
>
> **Homework Helper Math:** This is in all the schools so you should have seen it.
>
> **Visualizer:** This is an add-on to **Appleworks** and does pie-charts and bar-charts from spreadsheet data. It can also print out the graphs. We have a better version coming which works within

Appleworks, which is called **Time Out, Graph It.**

Dynamic Modeling: This is listed as a physics program but it allows you to build up equations, matrices, etc.

Artificial Intelligence: This could help with problem-solving but its not directly related to the syllabus.

The disks were then handed around among the participants, each of whom looked briefly at the cover and passed it on. No attempt was made to actually demonstrate any of the programs on the computers in the room.

The generalised approach to workshops did not give due emphasis to issues which teachers had to face in the integration of the technology into the curriculum. In view of their perceptions of difficulties associated with class management, current teaching methods and the usefulness of software, many teachers expressed reservations in relation to using the technology in formal lessons. Three representative examples are given below:

SMC at School P - 6.7.87
The RC can only accommodate half a class and the other half has to be left in the classroom. Teachers prefer traditional teaching methods and don't believe that the computers are better. Some subject teachers, for example English and Kiswahili, even after attending the subject workshop do not see how the computers can be used for teaching their subjects. Even the science software is more of a game than serious teaching. It may be good for revision but it is not useful for teaching a topic the first time.

Physics/Mathematics Teacher at School R - 7.10.87
There is too little time due to overloaded syllabuses, unsuitable software, current lack of space in the RC, the problems of taking pupils to the RC and leaving half of them behind, and the belief among teachers that the software is for revision and not for first-time teaching.

Mathematics Teacher at School U - 28.3.88
He said that he had gone to the RC and found that most of the students "were playing with cartoons", adding, "I am not going to be involved with that kind of education." He was aware that his predecessor in the department used to take classes to the RC "to play with various disks", but he said he did not know what disks were useful and did not know anything about using disks in teaching mathematics. He said that students had told him they wanted to go to the RC, but he had told them that he was not going to take them there until he had learned how to use the computers and had proved to himself that there was something useful in relation to mathematics.

The belief among teachers that most project workshops covered topics which were irrelevant to school subjects constituted one of the commonest criticism of the project among teachers. The criticism was directed at a wide range of workshop activities. Languages and humanities teachers complained of having to view science CAL programs at general workshops when no suitable programs were available in their subjects. Further, language and humanities teachers alleged that programming sessions were only for mathematics and science, and consequently of no benefit to the former. Mathematics teachers regarded LOGO sessions as being irrelevant to the teaching of the subject. Many teachers across all disciplines regarded applications sessions using the database and spreadsheet as a waste of time since they could not visualise how these applications could be used in their disciplines. In reference to a workshop in which software meant for other subjects was used in discussing the teaching of languages, an english teacher at school Q argued as follows:

> We did a lot of playing about using biology, geography and general knowledge software, but there was nothing there that was "serious" english.

Another teacher who had attended the language workshop pointed to the issue of cultural bias in software as follows:

> English Teacher at P - 16.10.87
> The programs to be used with the computers have been developed for a different education system which is not the same as Kenya's. We should not grab any technology just because we get it free.

Not all teachers were negative about the possibilities of integrating the technology into their teaching. A number of the early adopters were willing to venture into using the computer, however most of them complained of the difficulty they experienced in adapting to the approach of having to find out for themselves how the technology could be used in lessons. They expressed the view that a didactic approach in workshops was required. They argued that tutors needed to demonstrate in detail how particular programs could be used in lessons. The following three examples were representative.

> Head of School S - 21.5.87
> Teachers do not see where they could incorporate programs into their current teaching style. Software has been available in the school but teachers are ignorant of its potential. We need to be told straight what these things can do for us. We don't have the time for trial and error. We want to see demonstrations of the useful programs so that we can get and use them.

> Biology Teacher at School T - 25.6.87
> We teachers learned how to work with those programs ourselves but they did not tell us how to have students work with the programs.

Art Teacher at School R - 5.10.87
Teachers need to be shown how to use the computers with their classes and things that will be immediately useful. They want to see programs that can be used with their syllabuses.

In spite of the teachers' views, most workshops took the form observed by two different researchers as follows:

Observation at a General Workshop - April 1987
At no point did any of the instructors, who have used the computers in their teaching, give a demonstration of how they actually used specific software packages with students. There was no discussion with the participants as to the suitability of particular programs in specific subjects. It seemed to be assumed that software is inherently useful and immediately usable. Potential innovative and imaginative uses of particular programs were not explored, nor was there any mention of the preparation which the teacher should do in order to make most effective use of the technology.

Observation at a General Workshop - May 1988
The tutors tended to show off their knowledge and tended to feel their main point was to prove that the computer can do things fast. Generally, tutors failed to conceptualise the real tasks necessary in training other teachers.

After making observations at the April 1987 general workshop, another researcher expressed the following opinion:

It was clear that teachers need a lot of purging of the idea of content in the software being similar to that found in textbooks. A very serious and well thought out strategy needs to be developed so that when teachers come for the subject-specific workshops they can see how to use CAL software in their planning and teaching.

What most tutors in workshops do not seem to have realised was that even good software was neither tailor-made for the Kenya syllabuses, nor did it take the same form as the traditional print media. The innovative mathematics teacher, whose integration of the technology was discussed in Part 3, expressed the following view on one of the programs she had used imaginatively:

Mrs Anunda's Comment on Logical Games - 28.9.87
She said that it was not possible to use the program in its present format because it did not suit the levels of simplicity or complexity required by the students at various levels and the time allocation of 40 or 80 minutes.

In urging for imaginative review and use of software by teachers, the SMC at school R made the point which most workshop tutors ignored. He said, "There is a difference between a surface look at a piece of software and

real learning of the program because you want to use it. Many teachers just look at them but they don't want to learn how to use it. May be this is where we go wrong in teaching the students. We emphasize the wrong things, the things which are not important to them."

The failure of workshop tutors to meet the real needs of teachers was most glaring in sessions which aimed at imparting knowledge on the in-class use of general applications software, such as graphics programs, the spreadsheet and the database. Two tendencies were apparent in most sessions. First, tutors introduced the programs in general terms. For instance, the spreadsheet might be introduced as a useful number cruncher in mathematics and science; the database might be claimed as a useful tool in the classification of fauna and flora; participants might be informed that a particular graphics program could be used to build bar graphs or pie charts from data processed through the spreadsheet. Second, after the generalised introduction, the tutor would launch into a technical discussion of the mechanics of a program. The discussion would be followed by a hands-on session in which the example used was unrelated to those given in the general introduction. For instance, in the case of the database participants might be required to work with imaginary students' mark registers. In this process, the crucial link between the participants' existing knowledge of aspects such as classification in biology and the technicalities of the computer database would fail to be made. After observing a workshop database session in May 1988, a researcher made the point as follows:

> One of the key issues revealed by the tutor's strategy in introducing the database (DB) to participants was the essential component of planning for a DB file. There is really no point in inputting data until a teacher has understood what a DB is for. Telling a teacher that a DB is useful in keeping students' records is no good until the teacher has appreciated what he is likely to do with the records once they are compiled. Unless the teacher has a notion of what he will do with the file, he has problems in arranging the DB in a meaningful layout in the first instance. Teachers should probably first be introduced to a physical DB, then led through ideas of defining categories and standard values. They may then be asked to plan a simple computer DB which they use to learn to organise data of their own choice.

OPPORTUNITY COSTS INCURRED BY STUDENTS

The opportunity costs incurred by students were closely related to the management of time by schools. Three observations on management of time by the six schools were made. First, with the exception of Forms 5 and 6 classes, the official day was fully devoted to formal lessons. Second, the schools had schedules of extra-curricular activities (sports, clubs and societies) which took place after classes and during weekends. Third, with the introduction of the 8-4-4 curriculum, pressure on the official day had increased: 9 lessons (as opposed to 8 in the past) were

scheduled on each day. This development had the effect of reducing the time available for working with the computer as part of out-of-class activities schedule.[7]

Because of the foregoing pressures on time, students who wished to work on the computers had to make a number of sacrifices. Because Forms 1 to 4 students had no free periods during which they could on their own work with the computers, in order for them to go to the RC during formal lesson time they had to sacrifice lessons conducted in the normal classrooms. In-school interviews and observations indicated that some students were making this type of sacrifice. On a number of occasions, senior staff expressed concern that, instead of doing the work set for a lesson, some students would "abscond" to the RC whenever a subject teacher was absent. In school R, a deputy head was reported to have accused the SMC and one other teacher of "encouraging students to work with the computers whenever a subject teacher was absent." The SMC claimed that on one occasion, the deputy head had subjected a group of "guilty" students to severe punishment. In schools P and U, incidents of senior staff throwing students out of the RC at the end of morning tea and lunch breaks were witnessed by researchers. With regard to Forms 5 and 6, it was observed that in schools P, Q, S and U some students were spending most of their free periods on the computers. A case in point was the Form 6 leader of the computer club at school P, who was observed using all his free periods in a day (March 1988) to wordprocess notes on programming in BASIC. On being interviewed, he said that he was preparing the notes for the guidance of members of the club. Students who devoted most of their free periods to computer activities not related to the normal curriculum learned something new and probably of future importance. However, such students were making a choice to spend less time on their prescribed subjects of study. A similar choice was being made in relation to learning through participation in out-of-class activities. Some students were observed to be devoting the time after formal lessons to activities on the computers. Thus, such students chose to forego opportunities to experience growth through participation in games and sports, and non-computer clubs and societies.

In some computer-assisted lessons the students would appear to have been making a subtle sacrifice. As shown in Part 3, in the majority of computer-assisted lessons teachers tended to be passive, thus leaving students to do whatever they chose. Given that the computer is fascinating and that the students were naturally keen to freely explore the technology, some computer-assisted lessons took the form of unfocused activities. Some students regarded both formal and informal sessions on the computer as time for relaxation as opposed to serious learning. Observation of students working with the computers indicated that

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7. Pressure on time was observed to be less severe in the two boarding schools (P and S) in the project. Since in the two schools the students and most teachers lived in the school compounds, activities could be planned to take place in the evenings of working days and during part of the weekend.

experimentation with the functions of the keyboard and/or production of interesting screen displays was regarded by some students as more important than mastery of the subject content of a particular program. Further, computer-assisted lessons were in some cases characterised by too much noise and unruly behaviour. From the foregoing it can be inferred that, by making learning an unfocused activity, some computer-assisted lessons inhibited students' mastery of the set curriculum.

GENDER ISSUES IN STUDENTS' USE OF THE TECHNOLOGY

Discussion of data collected in the pilot study (Table 3.17) indicated that there was a contrast between the views of male and female students: (a) 31% of the female students, as compared to 13% of the males felt that computers "make school work easier and/or faster" (b) 15% of the male students, as compared to 4% of females, felt that the introduction of computers into the school was "useful preparation for future career." However, some of the data collected during the Phase II study painted a different picture in the six schools. Analysis of data collected from the much larger samples in the 1988 survey revealed no significant differences between the attitudes of male and female students with regard to: (1) perceptions of the degree of difficulty in the technical mastery of the computer (2) the role of the technology in further education and specified future careers (3) the potential of the technology as a learning resource. Table 4.04 shows the percentages of boys and girls who strongly agreed with six statements on the use of the technology in formal lessons.

Whether for the total sample, girls in the four mixed schools, or girls in the two girls schools, the data in Table 4.04 show that the views of female students closely approximated those of the males. The responses in Table 4.04 were very similar to those registered in Table 3.24 for the same items but analysed for each school and the total number of respondents.

However, in some of the 1988 survey questions which did not directly elicit for attitudes to the technology, analysis of students' responses indicated that there were differences between male and female perceptions of the technology. School U, where most students had been exposed, illustrated this point in a subtle way. Two items in the questionnaire required a student to indicate whether or not (a) there was a computer in his or her home (b) he or she had used a computer outside the school. Table 4.05 shows percentages of school U male and female students who responded positively to the two items.

The data in Table 4.05 show that with regard to the two channels of exposure outside the school, female students were more disadvantaged than their male counterparts. The proportion of males who claimed to come from a home which owned a computer was nearly twice that of females, while 21% more boys than girls claimed to have used a computer outside the school. Assuming that most students in the school came from similar socio-economic backgrounds, the male-female differences in the table

Table 4.04. Percentages of Students Strongly Agreeing With Statements on Use of Computer in Lessons.

	Total Sample M	F	Girls in P,Q,T & U	Girls in R & S
A. The computer allows you to learn at your own speed	61	64	59	67
B. Learning with a computers is best for revision	50	56	49	60
C. Learning with a computer is more interesting than learning with a teacher	44	43	41	44
D. Computer program explanations are easier to understand than the teacher's	15	16	10	19
E. Using computers takes time away from your studies	12	13	11	12
F. Computer-assisted lessons are not as interesting as ordinary lessons	7	10	8	11

Notes:
1. Abbreviations: M = Male, F = Female.
2. Schools P, Q, T and U had both male and female students. Schools R and S had female students only.

Table 4.05. Percentages of School U Students With Exposure to Computers Outside School.

	Male	Female
There is a computer in my home	25	13
I have used a computer outside the school	69	48

could not be explained by differences in such items as affluence or level of parents' education. Discussion of some of the data on in-school implementation provide clues as to alternative explanations.

In school U, 389 students (90% of the enrolment) indicated that they had personally operated the school computers. The mean number of times male students had personally operated a school computer during the third term of 1988 was 10.9 as compared to 7.5 for female students. Thus, as in the

case of exposure outside the school, female students claimed to have received less in-school exposure than the males. With regard to all six schools, this claim surfaced in other data collected during the 1988 survey. Analysis of the responses as to the times during the school day and week when students used computers indicated that, in contrast to males, female students had less time in which to work with the computers (Table 4.06).

According to the data in Table 4.06, in school U much smaller proportions of females, as compared to males, reported to have worked with the computers after classes, during the lunch break or during time set aside for computer club meetings. With regard to the whole sample and girls in the two other categories (mixed and girls only) the pattern is repeated in relation to the period after classes. For the whole sample, the proportion of males who worked with the computer during the weekend was two and half times that of females. What were the reasons for the foregoing female under-exposure?

One explanation seemed to be the observed fact that in day schools most parents were unwilling to let girls stay on in school for informal use of the computers after formal classes. It was observed that in schools Q and U, where a considerable number of students travelled to and from school by private cars, soon after formal lessons most girls would be driven away. In an interview with several teachers in the two schools, it was confirmed that most parents felt that allowing girls to participate in unsupervised computer activities after formal lessons exposed the girls to possibilities of misconduct. This element of social control may also have resulted in some girls being forbidden to return to school to work with the technology during the weekend. In contrast, most parents were willing to allow boys to work with the technology after formal lessons and during weekends. However, the foregoing does not fully explain why comparatively smaller proportions of females worked with the technology outside formal lessons. For instance, more strict

Table 4.06. Percentages of Students Using Computers During Specified Times in the Day and Week.

	Total Sample		School U		Girls in	Girls in
	M	F	M	F	P,Q,T & U	R & S
Formal lessons	45	46	70	85	61	39
Free periods	30	18	47	50	31	12
Lunch break	9	9	20	12	8	11
After classes	24	7	31	7	11	6
Weekends	15	6	2	3	10	4
Computer club	17	9	9	2	6	11

Notes:
1. Abbreviations: M = Male, F = Female.
2. Schools P, Q, T and U had both male and female students. Schools R and S had female students only.

parental control over girls does not explain why in school U only 12% of females (as compared to 20% of males) worked with the technology over the lunch break. What other explanations were there?

In an item in the questionnaire, students were asked which of specified software they had personally used. The responses of students in school U are shown in Table 4.07.

As indicated in Part 3, in school U subject specific CAL software was used by most students mainly during formal lessons. Thus, according to the data in Table 4.07, it is not surprising that about two thirds of males as compared to three quarters of females had personally used a CAL program. Elsewhere in Part 3, it has been shown that computer games and the two graphics programs, **Mousepaint** and **Printshop**, were used by students mainly outside formal lessons. It is thus significant that much larger proportions of males claimed to have played computer games and personally used **Mousepaint** and **Printshop**. To an extent, relatively lesser female involvement in computer games and the two graphics programs could be explained by the limited access to the technology which was associated with parental social control. However, it would seem that some female students were not positively disposed to computer games or to some of the other software provided by the project.

The literature on gender inequity in education is replete with findings that in most societies, females are disadvantaged with regard to learning in mathematics, science and associated technical disciplines. Republic of Kenya & UNICEF (1984), Papanek (1985), Jones (1985), Partington (1985), Drass (1986), Blossfeld (1987), Collis (1987), Persell & Cookson (1987), and Damarin (1989), report studies which show that mathematical, scientific and technical subjects, and related careers are widely regarded as masculine domains and that, whether covertly or overtly, formal education systems inculcate this belief in school students. Eshiwani (1982) and Obura (1985) adduce convincing evidence to show that by the time most Kenyan girls complete primary school they have been socialised by society, parents, the school system, teachers and biased

Table 4.07. Percentages of School U Students Who Had Used Specified Computer Software.

N = 423	Male	Female
Computer games	90	75
Mousepaint	91	62
CAL program	67	75
LOGO	66	56
Wordprocessor	56	59
Printshop	61	26
Database	27	26
Spreadsheet	27	26

learning materials into believing that mathematics and science, and the careers into which they lead, are meant for males and not for females. As a consequence, many girls who enter secondary school decide to opt out of these subject areas at the earliest possible opportunity. It would seem that in the CEPAK schools, the nature of exposure to computers - shown to have been more significant in the sciences and mathematics as opposed to languages and humanities - to an extent served to strengthen the belief that computers require a lot of mathematical and scientific knowledge and thus, convinced some female students that the innovation was really meant for their male peers.

In Table 4.07, the responses to personal use of the wordprocessor and LOGO, contain clues as to different male and female dispositions to the technology. Like the database and the spreadsheet, the wordprocessor and LOGO were noted to be part of the IT and computer studies courses in school U. The wordprocessor was also used in a number of out-of-class activities. At least 56% of male and female students claimed to have worked with wordprocessor and LOGO, a claim which indicated much more use than was the case with regard to the database and the spreadsheet. It is significant that 3% more females than males claimed to have personally worked with the wordprocessor, while 10% more males than females made a similar claim in relation to LOGO. These data suggest that wordprocessing (associated with typing classes which predicated future career as a secretary) was perceived as an important female domain, while LOGO programming (with its distinctly mathematical orientation) was perceived as a predominantly male domain.

A strong male orientation in the technology was also implicit in some of the computer games available in the project. Review of 17 CEPAK programs catalogued as educational games revealed that 15 (88%) were based on content and approaches which, at least in the Kenyan context, was biased in favour of males. The following 9 of the 17 games were observed to be popular during after school computer activities, particularly in school U.

Title	Content
Tycoon	Commodities market
Squire	World of high finance
Millionaire	Stock market
Baron	Real estate market
Flight simulator	Aircraft pilot training and aerobatics
Snooper Troops Case	Detective work
Elite	Navigation and flying, interplanetary travel, intergalactic trading, political profile of the universe

Space Shuttle	Simulation of NASA's space shuttle discovery
High Seas	Simulation that puts the student in command of the most powerful ships of the 17th to 19th centuries.

After reviewing the 9 programs above, a researcher expressed the following opinion:

> While one does not deny the right of women to wage war, command ships and aircraft, wheel and deal in the stock market, and engage in interplanetary travel, it must be obvious that in most countries women do not engage in these activities. Certainly no Kenyan women are engaged in them and the masculine nature of these games must subtly put forward the view that computers, and especially computer games, are for boys rather than for girls.

Thus, the finding in Table 4.07 that 15% fewer girls than boys at school U had played computer games should partly be attributed to the masculine bias in the software. Observation data at the four mixed schools in the project indicated that during out-of-class computer activities, the proportions of girls in the RCs were far below the female representation in the total enrolment. The following extracts from researchers' field reports illustrate the point.

> Observation at the RC in U on 19.5.87 after Formal Lessons: At one stage the number of students rose to 27. It was noticeable that all the students were boys, but at one stage two girls came in. However, the girls were reluctant to get to any machine even when one was free. They were quite content to chat and watch whatever was going on. Eventually the two girls joined one boy who was playing a maze game, but they just sat and looked. Another boy joined them and tried to show them how to use the joystick, but they were reluctant to try for themselves.

> Observations at the RC in P after Formal Lessons:
> On 7.7.87 - Of 14 students observed using the computers, only 2 were girls who worked on their own and not with the boys.
> 14.10.87 - Out of 17 students observed using the computers only 2 were girls.
> 15.10.87 - Of 8 students observed using the computers only 2 were girls.

Some of the data obtained through the students' questionnaire indicated that a significant proportion of male students had internalised the wider society's prejudice to the effect that new technology is a male domain. In the total sample, 73% of respondents strongly disagreed with the statement that "in future computers will be more useful for boys than for

girls", a stand supported by 76% who strongly disagreed with the statement that "using the computer is easier for boys than for girls." However, when the responses to the two statements were analysed for boys and girls separately, a different picture emerged as follows:

	% of Students Strongly Disagreeing	
	Male	Female
Computers will be more useful for boys than for girls in life after school	57	81
Using the computer is easier for boys than for girls	63	83

These data show that more boys than girls felt that there were innate gender-based differences in relation to the mastery of the technology and its future use in the work- place. Within the student body there seemed to be
deep-seated belief that females are different from males to the extent that the former are irrational, unscientific and naturally lacking in technical knowledge. The following jokes, published in two issues of school U's magazines, illustrate male digs at females:

English Literary Society Magazine - 1987

a. One evening when all our lights suddenly went out, I asked my mother to check if the street lamps were off. "Yes", she said, "but it can't be a power cut, all the cars still have their lights on."

b. A cab picked up a woman passenger who was on her way to take her driving test. En route, the driver asked the passenger how she was going to take the test without a car. "Oh", wailed the woman, "I knew I'd forgotten something."

School Magazine - 1987

a. Having asserted that "chemical analysis of a woman is an accepted concept in bio-chemistry", the author, likening woman to a metal, proceeded to define her physical properties as follows:
"(1) Surface usually painted with film.
(2) Boils at nothing, freezes without reason.
(3) Melts if given proper treatment.
(4) Found in various stages ranging from common metals to virgin metals.
(5) Bitter if used incorrectly.
(6) Non-magnetic but attracted by coins and sports cars.
(7) In its natural state it varies considerably but shape is often changed so well that the change is indistinguishable except by experienced eyes."

b. EXECUTIVE TO PERSONNEL MANAGER: "My secretary spells like a mathematician - she rounds off to the nearest letter of the alphabet."

Belief that mathematics, science and technology were naturally unsuitable for females was not confined to the student body. As indicated by the following three extracts from researchers' reports on workshop and in-school observations, some teachers held views not unlike those held by some male students.

> Female SMC in School S at a Workshop on 27.8.87
> During a discussion on the potential of LOGO, she said, "Anything to generate interest in maths in girls' schools would be most helpful."
>
> Male Physics Teacher at School S on 29.9.87
> "Girls are a bit slower in learning physics than boys, but the good ones are very good and are especially careful and precise, more so than boys."
>
> Male Physics/Maths Teacher in School R on 5.10.87
> "The girls in the school have a very negative attitude to both maths and physics. They are programmed by their friends to believe that the two subjects are difficult."

The fact that the foregoing extracts were recorded from teachers in the two girls' schools in CEPAK indicates that negative perceptions of the female role in mathematics, science and technology was not confined to the four mixed schools in the project.

In the survey data collected by Gakuru and Kariuki[8], the students who felt that there was a gender-based difference in the dissemination and reception of the innovation were asked to suggest explanations. The following explanations given by some of the students were representative:

A. "The girls don't seem to catch onto computers: they just don't understand." - Form 2 Male

B. "Boys think girls do not know anything and that the former are cleverer than the latter." - Form 2 Female

C. "I think the boys have a way with computers whereas girls sometimes take time." - Form 3 Female

D. "The boys are more interested than the girls are." - Form 6 Female

E. "The girls use the computer very few times." - Form 3 Male

F. "The difference I think is that girls get a lesser chance in using computers." - Form 2 Male

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8. Gakuru, O.N. & Kariuki, P.W. Computers in Education at the Aga Khan Academy Nairobi, Kenya: A Study of the Impact of the Innovation, 1986.

The six explanations seem to have represented three sets of issues. Explanation A represented the typical masculine attitude to female involvement in what is considered technical, scientific and mathematical, and therefore a male domain. Explanation B represented female frustration with wholesale masculine denial that females have a role to play in technical and scientific spheres. Explanations C and D took the debate beyond recriminations between the two sexes: there was admission by representatives of the two sexes that, for unstated reasons, the males are more interested in computers than the females. Explanations E and F, both given by males, attributed lesser interest among female students to limited opportunities to work with the technology.

The foregoing explanations by students in the pilot phase were extensively collaborated by observation data collected in the Phase II study. Observation of computer-assisted lessons consistently came up with two patterns as follows.

First, because most teachers allowed random grouping, in most computer-assisted lessons involving grouping girls stuck together and, if they could help it, avoided mixed groups. The following examples, quoted from the relevant field reports, illustrate the point:

> School U: Form 1 IT Observed by PD on 11.2.87
> The class divided into 2 main groups. These two groups divided according to sex.
>
> School Q: Form 6 Economics on 16.3.87
> Of the 15 students, the 9 girls formed one group while the 6 boys formed the second group.
>
> School U: Form 1 Chemistry on 2.7.87
> The class divided into 5 groups. Two of the groups were all girls, while the other groups were all boys.
>
> School Q: Form 5 Biology on 6.7.87
> Of the 12 students, 6 boys were at one micro and 6 girls at another.
>
> School U: Form 2 Chemistry on 15.2.88
> There were two sets of groups, one on computers and the other working on non-computer exercises. The 7 groups on computers were as follows: 3 girls, 4 girls, 4 girls, 4 boys, 3 boys, 4 boys and 3 boys. The 4 groups on non-computer tasks were as follows: 4 girls, 6 girls, 2 girls and 2 boys.

The girls reluctance to freely mix with boys was not surprising. In several computer-assisted lessons observed, there was a considerable amount of playing about and disruption of learning, with boys being the main instigators of the unruly behaviour. It was only natural that the girls should seek to avoid possible teacher sanctions by keeping to themselves. There may also have been an element of the girls wishing to avoid ridicule from the boys if the former made serious operating errors.

Further, by making sure that she was in all girls' group, a female student ensured that she could successfully compete for a chance to personally operate a computer during the lesson.

The second pattern had to do with participation in lesson activities. It was noted that there was a tendency for boys to muscle their way into control of the computers at the beginning of lessons and, unless the teacher intervened, to continue dominating the keyboard and often the discussion for most of the lesson. A researcher recorded the following opinion of a student at school U:

> Nasleen - Form 1 in U - 1.8.88
> "When in the RC for classes, there is no definite decision as to who should operate the micro keyboard. It's usually whoever gets there first, most times the boys."

Partly because of the tendency for boys to dominate activities in computer-assisted lesson, in mixed classes most girls tended to be passive. Lesson observation reports were littered with statements such as the following:

> School T: Form 1 English on 19.5.87
> The girls were happy to leave the keyboard to the boys.

> School U: Form 1 Chemistry on 2.7.87
> The teacher did change the keyboard operators around but it was noticeable that some of the girls at the back of their groups seemed very bored by the whole thing.

> School U: Form 2 IT on 2.7.87
> The teacher visited each of the groups in turn, giving any help that was required and ensuring that the students on the keyboard rotated so that each one got a chance to operate the micro. One drawback was that those not operating the keyboard had nothing to do. Some gave hints to the keyboard operator, some just sat there with bored expressions on their faces (especially the girls). At one point a girl remarked to her group, "All this is so boring."

> School U: Form 5 Biology on 28.9.87
> Group 3 had one keyboard operator, a boy. The other two members of the group, both girls, spent most of the lesson discussing their weekend activities.

> School U: IT Lesson on 15.2.88
> The 15 students were in the following groups: 2 girls, 2 girls, a boy and a girl, 3 boys, 2 boys, 2 boys and 2 boys. The group of a boy and a girl was dominated by the boy, with the girl content to let him do most of the calculations and operate the keyboard. After a while the teacher noticed the passiveness of the girl and required her to take over the keyboard. But even then, the boy continued to be the source of the data being

keyed in by the girl.

To summarise, the computer was being introduced into a school setting which was already characterised by deep- seated prejudices in relation to female education in mathematics, the sciences and technical subjects, as well as the careers into which these disciplines lead. These prejudices, together with the masculine orientation in some of the software, had the effect of limiting the participation of female students in the innovation. The implications of this inequity in the learning situation should be obvious. As teachers attempt to disseminate computer technology to students and, more important, as the overall learning experience is planned and implemented, there is need for school staff to be conscious of the existence and dangers of gender stereotyping. Learning experiences which ignore the special needs of female students fall short of the goal of ensuring equality in the development of all children entrusted to a school.

Part 4 dealt with issues which in a sense amounted to the non-monetary costs of the innovation. In Part 5, the discussion turns to the monetary costs of Phase II.

PART 5

MONETARY COSTS OF CEPAK PHASE II

DONOR INVESTMENTS

As indicated in Part 1, four donors were involved in funding Phase II of CEPAK. The Aga Khan Foundation (AKF) both provided most of the donor funds and the infrastructure for the management of the project. AKF met 71% of all donor expenses on the project, including the costs of the research component. The other three donors made valuable contributions to the project as follows. Apple Inc. of the USA donated hardware and software worth about US$ 77,200 or about 47% of the capital expenditure of Phase II. The International Development Research Centre (IDRC) of Canada and the Rockefeller Foundation (RF) made contributions towards the research component. IDRC and RF donated US$ 62,000 and 30,000 respectively; thus the two donors met 28% and 13% of the total research expenses.

Tables 5.01, 5.02 and 5.03 respectively show actual donor expenditures on, capital goods, recurrent activities and research costs of Phase II. The data in the three tables were obtained from the records of the research team, the PD, and the Nairobi offices of AKF and the Aga Khan Education Service (Kenya). Originally Phase II was planned to end in December 1988, but a six month extension was funded by AKF. As per the original plan, the study discussed in this report relates mainly to data collected up to December 1988. Thus, Tables 5.01 and 5.02 do not show the costs of the six month extension. With regard to the research component, the expenses in Table 5.03 include the costs of data analysis and report writing during the period January to September 1989.

Table 5.01. Phase II Capital Expenditure (US $).

	Number	Unit Cost	Total Cost
COMPUTER HARDWARE			
Apple IIc	1	1,299	1,299
Apple IIc Portable bundle	1	1,228	1,228
Apple IIe (English)	25	384	9,600
Apple IIe (French)	6	384	2,304
Card 1M flipper	2	455	910
Card 256K	8	312	2,496
Card 32K buffer	2	91	182
Card clock	2	156	312
Card colour DMS	22	81	1,782
Card controller 140K	18	26	468
Card controller 800K	33	33	1,089

Card Ext. 80 column	36	104	3,744
Card reader	1	1,820	1,820
Card super serial	28	117	3,276
Covers, equipment	96	12	1,152
Disk drive IIc	1	325	325
Disk drive 140K	2	260	520
Disk drive 140K UNI 5.25	18	260	4,680
Disk drive 800K	42	364	15,288
Disk profile Hard 5Mb	2	650	1,300
Joysticks	13	34	442
Lazer printer	1	6,000	6,000
MacCharlie system	1	1,755	1,755
Macintosh 512K	1	1,820	1,820
Macintosh keypad	1	260	260
Macintosh mouse	1	65	65
Marbo power cable	1	20	20
Mastercard II + cable	5	65	325
Modems	8	65	520
Monitor, colour large	6	670	4,020
Monitor, colour small	16	442	7,072
Monitor, monochrome IIc	1	195	195
Monitor, monochrome IIe	35	117	4,095
Mice	20	101	2,020
Nightngale accessory board	5	65	325
Numeric keypad	2	90	180
Plotter Apple colour	2	780	1,560
Printer cable 1M	22	26	572
Printer changers	2	85	170
Imagewriter 15"	1	682	682
Imagewriter II	23	345	7,935
Printer cable	2	20	40
Ram expansion kit	9	312	2,808
Robostick 500	2	383	766
Socket, 4-way	30	9	270
Soldering station	1	104	104
Storage box 3.5"	9	23	207
Storage box 5.25"	15	29	435
Systems saver	35	85	2,975
Tool kit	2	260	520
Transformer 110V	1	26	26
Sub-total			**101,959**

SOFTWARE, MEDIA & EDUCATIONAL MATERIALS

Software			12,600
Disks 3.5"	619	4	2,476
Disks 5.25"	150	3	450
Books			1,540
Sub-total			**17,066**

OTHER HARDWARE			
Audio-cassette recorder	3	124	372
Overhead projector	3	273	819
Manual Shredder	1	103	103
Photocopier	1	2,580	2,580
Printing Press	1	8,776	8,776
Slide projector	1	1,209	1,209
TV, colour 26"	1	500	500
Video camera	1	1,527	1,527
Video recorder	2	780	1,560
Video tapes	30	7	210
White board	8	110	880
Estate car	1	7,980	7,980
Furniture			5,871
Sub-total			**32,387**
OTHER EXPENSES			
Freight charges			8,180
Office modifications			5,472
Sub-total			**13,652**
GRAND TOTAL			**165,064**

Table 5.02. **Phase II Recurrent Expenditure, 1986 - 1988 (US $).**

	1986	1987	1988	Total
LOCAL PURCHASES				
Stationery	1,136	2,082	2,589	5,807
Printing press supplies			1,585	1,585
Telephone/Postage	783	2,124	2,191	5,098
Rent	1,238	2,329	2,422	5,989
Services	437	581	547	1,565
Maintenance	570	3,142	4,587	8,299
Insurance	1,650	2,767	2,933	7,350
Sub-total	**5,814**	**13,025**	**16,854**	**35,693**
OVERSEAS PURCHASES				
Software		11,830	7,639	19,469
Books		2,608	1,195	3,803
Subscriptions		2,964	1,234	4,198
Media (disks etc.)		5,349	2,139	7,488
Other materials		1,951	645	2,596
Sub-total		**24,702**	**12,852**	**37,554**

TRAINING EXPENSES				
Air Fares (PD)	175	788	917	1,880
Overseas travel (PD)		5,328	3,501	8,829
Per Diem (PD)	3,325	7,341	5,789	16,455
Motor vehicle (PD)	412	2,290	1,992	4,695
Tutor fees	600	3,659	2,645	6,904
Teachers' travel	468	3,174	2,322	5,963
Per Diem (Teachers)	1,190	7,431	10,012	18,633
Sub-total	**6,170**	**30,011**	**27,178**	**63,359**
PERSONNEL COSTS	11,016	24,235	26,458	61,709
GRAND TOTAL	**23,000**	**91,973**	**83,342**	**198,315**

Note: The project office did not have a separate meter to monitor its consumption of electricity. The office supply was paid for by the school which hosted the office, with reimbursement being done through payment of rent for the premises.

Table 5.03. Phase II Research Expenses, 1986 - 1989 (US $).

	1986	1987	1988	1989	Total
CAPITAL EXPENDITURE					
Furniture	1,313				1,313
Computer hardware	6,415				6,415
Software	3,800	491			4,291
Dictaphone		1,049			1,049
Car		8,844			8,844
Sub-total	**11,528**	**10,384**			**21,912**
PERSONNEL					
Research fees	15,998	36,537	35,319	30,446	118,300
Secretary	1,613	6,360	7,133	3,977	19,083
Sub-total	**17,611**	**42,897**	**42,452**	**34,423**	**137,383**
LOCAL TRAVEL					
Air fare	459	468	459	605	1,992
Car expenses	1,548	2,658	3,185	3,058	10,449
Per diem	1,813	3,496	1,594	8,039	14,942
Sub-total	**3,820**	**6,623**	**5,238**	**11,702**	**27,383**
OVERSEAS TRAVEL		3,929	3,688	2,986	10,603
CONSULTANTS	16,846	1,073		1,750	19,669

OTHER EXPENSES					
Meetings		68	267	173	509
Services	94	313	375	388	1,169
Supplies	188	375	699	500	1,762
Telephone/post	63	561	566	375	1,564
Books	49	256	158	470	932
Insurance	63	175	188		425
Sub-total	455	1,748	2,252	1,906	6,361
GRAND TOTAL	50,260	66,652	53,629	52,767	223,309

According to the data in Tables 5.01 to 5.03 the total donor expenditure on Phase II was US $586,687. Of this total, the proportion of the research component was 38%. Of the $363,379 spent on the actual project (i.e. the grand total less research costs) the capital expenditure constituted 45% and thus the proportion of recurrent expenditure was 55%. Within the recurrent expenditure component of the actual project the proportions of the four sub-heading were : local purchases - 18%, overseas purchases - 19%, training expenses - 32% and personnel costs - 31%. If it is assumed that the project personnel was hired mainly for the purpose of undertaking the training of school staff, it could be argued that of the total recurrent expenditure of Phase II, 63% went into training.

SCHOOL COSTS

As indicated in Part 2, the project was not wholly donor funded. The schools had to meet a proportion of the project's capital and recurrent expenditures.

Capital Costs

The major capital cost incurred by the schools was in connection with installation of burglar-proofing and suitable electrical wiring in the RCs, and providing trolleys to facilitate movement of the hardware. There were considerable variations in the capital expenditures of different schools. In October 1986, each of the heads of P, Q, R and S claimed to have spent the equivalent of US $700 on converting a classroom into an RC. In March 1988, the bursar at school T indicated that modifications of computer rooms at the school cost a total of $2,341. However, it was observed that in school T, modifications had been carried out with regard to two RCs as well as the bursar's office.

Recurrent Costs

Since no donor funds were allocated for the items, the schools obviously incurred project-related costs with regard to electricity, telephone and

postage. Every three months, the project provided each school with one box (9.5" x 11", one ply A4 paper) of continuous computer stationery. There is evidence that this supply of paper was regarded as inadequate by the schools and that they made an effort to supplement it from their own resources. The following extracts from researchers' reports illustrate the point:

> School R - March 1988
> The deputy head pointed to a relationship between the project and increased consumption of stationery. She said, "Consumption of paper has gone up since the arrival of the computers, but I couldn't say by how much. People who use **Printshop** have to use duplicating paper and not computer stationery. Last year we ran out of duplicating paper and stencils for printing the end of year examinations. If more people use the computers it will be a problem."
>
> School T - March 1988
> All printing that was observed during the week was on the A4 or A5 normal duplicating paper provided by the school.
>
> School S - June 1988
> With regard to stationery the SMC said, "We use duplicating paper all the time for printing. I cannot remember when we used any of the other paper. I told the head to keep in her office the box of computer stationery received from the project."

Because schools did not keep separate expenditure accounts for the project, it was not possible to arrive at accurate figures on the school's recurrent costs of the innovation. However, some indication of the schools' recurrent expenditure was given by data obtained from two of the schools. In March 1988 the bursar at school T said that although there had been no change in the unit cost, the school's expenditure on duplicating paper had gone up from US $652 in 1986 to $1,467 in 1987. It is likely that the additional expenditure to an extent reflected an increase in handouts produced on the computers. The bursar said that in 1987 the school had paid $349 more for electricity than had been the case in 1986, but he quickly added that between the two years there had been a rise in the power tariff. In March 1988, the bursar at school U said that in 1987 the school spent a total of $1,831 on computer-related activities (computer ribbons - $384, computer paper - $690, repairs and maintenance - $757). Without giving any actual comparative amounts, he indicated that the introduction of the computers had led to a 20% increase in the school's electricity bill.

PROSPECTS FOR REPLICATION OF THE INNOVATION

As indicated in Part 1, one of the objectives of instituting a detailed study of CEPAK was to explore the possibilities of replicating the computer innovation on a wider scale. The desirability of replication depends on evaluations of costs, effects, and broader individual and

social benefits that can come from projects like CEPAK compared with alternative uses for the same educational resources. In Part 7 there will be a more comprehensive discussion of possible approaches to project replication. In this section we examine some cost and financing dimensions of this issue that affect both the desirability and the feasibility of undertaking projects similar to CEPAK on a larger scale.

To estimate the costs of a large-scale project based on the CEPAK experience would require a separate study. This study would have to define the context in which the project was to be implemented, make decisions about what features of the threshold package approach would be retained or modified, as well as what kind of training would be needed, what configuration of hardware and software would be purchased, what their prices would be, to name a few of the many estimates and assumptions necessary.

While to do such a study is beyond the scope of this report, it is possible to use the CEPAK cost information given in the previous two sections to compute a rough approximation of the per student costs that might be faced in a larger- scale CEPAK-like system. It should be noted that, even though CEPAK philosophy may consider students more as indirect beneficiaries and that, in practice, many students did not use computers, it is still appropriate to consider costs on a per student basis. Doing so is useful from the standpoint of planning expansion or start-up elsewhere and from an evaluation perspective which compares this type of educational innovation with the costs and effects of providing or improving textbooks, libraries, in-service teacher education, etc.

Table 5.04 summarises our best estimates of start-up and recurrent costs on a per student basis for a system like CEPAK.

Although the costs in Table 5.04 are based on an actual project, a number of assumptions have to be made and these are spelled out in the table footnotes. Chief among them is that the lifetime of the start-up costs - hardware, software and school modifications - is five years (and that the appropriate discount rate for public sector investments is 10%). It is also assumed that cost data based on expenses incurred earlier in the project still reflect costs in 1988. This is plausible for the threshold package hardware and software, since although there has been inflation, there has also been a reduction in real prices in some areas of the computer industry. Finally, it is assumed that no special research and evaluation effort would be made in a larger scale system.

Table 5.04 indicates that the annual equivalent cost per student of a project like CEPAK might be about US$ 44 (estimates were rounded to the nearest US$ .10). Most the cost, almost US$ 14 or 31% of the total was the amortized value of the threshold package. Additional software purchases each year made up another 13% of the total, almost US$ 6 per student per year. Almost all the remaining expenditures were for the training and administrative expenses associated with running the project. Direct training and workshop expenses were almost 20% of system costs, and administrative personnel and operations were 19% and 12% (with much

Table 5.04. Per Student Costs of a CEPAK-like Project[1] (in 1988 US $).

Cost Component	Cost/Student	%
Start-up Expenses		
Threshold Package[2]	13.70	31
School Modifications[3]	.50	1
Recurrent Expenses		
Project Admin. Personnel[4]	8.30	19
Project Admin. Operations[5]	5.30	12
Training/Workshop Resources[6]	8.50	19
Software/Materials Purchases[7]	5.90	13
School Operations[8]	1.80	4
Total	44.00	99

[1] Table 5.04 provides rough estimates of what a project like CEPAK might cost based on the CEPAK cost data presented in the previous two sections (assuming that no research component is included). The cost data above is intended to reflect 1988 US$ to the extent possible (principally, one needs to assume that the inflation for the threshold package cost is offset by hardware and software price decreases). Start-up costs (both for the threshold package and for the school modifications) are annualised over an assumed 5 year lifetime and an assumed 10% social discount rate. All cost component estimates are divided by the total enrolment in the six schools, 3190, except for the school modifications and school operations categories. The costs of these latter components were based on the 5 new Phase II schools only and thus are divided by an enrolment of 2750.

[2] Annualising the total hardware and software costs given in Table 5.02 of US$ 165,543 over 5 years at 10% yields an annual equivalent cost of US$ 43,543, or US$13.70/student.

[3] Based on modification cost estimates of US$ 700 for each of 4 new schools and US$ 2341 for the fifth, total modification costs were US$ 5141. Annualised over 5 years at 10% yields an annual equivalent cost of US$ 1356 or US$ .50/student.

[4] This is based on the 1988 project personnel costs of US$ 26,458.

[5] This is based on 1988 training expenses of US$ 16,854.

[6] This is based on 1988 training expenses of US$ 27,178.

[7] Purchases of software and other materials reflect an average of the US$ 24,702 spent in 1987 and the US$ 12,852 spent in 1988.

[8] Given the difficulties the schools had making estimates of the project's impact on their annual costs, a rough guess of $1000 per school per year (for the new schools) was used.

of these really being training expenses). Perhaps the weakest estimate is of school recurrent costs. However, even if the estimate is off, school recurrent costs form a small proportion of system costs. If average costs per school are US$ 1000 then these expenses are just 4% of total costs (which, of course, does not mean schools can afford that, as per discussion below).

If the US$ 44 per student estimate is reasonably accurate of the costs of similar larger-scale projects, then the evaluation question becomes what we get for this vis-a-vis other possible secondary school improvements that could be purchased with this money. This, of course, intersects with a feasibility question. As indicated in Part 1, the World Bank estimated that in 1983 the public recurrent expenditure per secondary student was US$ 74. This amount converts to 1988 US$ 86.[1] Thus, the US$ 44 estimate for CEPAK represents 51% of the average public costs of educating one student. It should be obvious that, even a modest threshold package of computer hardware and software for schools must be weighted carefully against competing priorities. For a start, account should be taken of expenditures, such as teacher salaries, which cannot be foregone in exchange for computerising schools. For instance, since (as indicated by the 1987-88 public budget) teacher remuneration consumes about 80% of recurrent expenditure on education, it would not be possible to contain within the public allocation the 51% of the 1988 per student cost which, as suggested above, would be needed for a CEPAK-like project.

The US$ 44 estimate from CEPAK may exaggerate the costs of a larger scale system. The estimate of hardware and software lifetime may have been too conservative. With the level of expenditure in the project budget for repair and annual software purchase, it may be possible to cover the gradual replacement of initial software and extend the life of hardware substantially. For example, if it were assumed that the threshold package had a 10 year life instead of the 5 years in Table 5.04, per student costs fall from US$ 13.70 to US$ 8.40.

Also, in a larger project it may be possible to achieve economies in training. While it may be difficult to reduce training costs if most training were carried out in-school, in a larger system it might pay to have intensive centrally located courses for a large number of teachers, combined with less-intensive subsequent in-school training. Moreover, although in-school training could be continued indefinitely given the endless array of new hardware and software, in practice, after a few years, such training could be reduced to very moderate levels or discontinued entirely. In-school users could continue the within school dissemination process. Thus, the project administration and training costs in Table 5.04 could perhaps be reduced substantially in a larger-scale, longer-run project. Costs might be both lowered initially and tapered off over time, thus essentially making the initial expenses

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1. The conversion is based on the US GNP deflator which was 103.9 for 1983 and 121.3 for 1988 (US Congress. Economic Indicators, August 1989).

capital costs that should be amortized.

If the threshold package had a useful lifetime of 10 years and if training and administrative costs could be reduced, say by 50%, through economies of scale and alternative training structures, then the cost of US$ 44 per student might be reduced to US$ 28. If after a few years, training could basically be carried out by within school computer users and administration handled as a normal part of school management, then average costs per student might be as low as US$ 17. But all this is clearly speculative and should serve to point how the costs of replication depend critically on the design and context of the proposed system.

While external aid may provide some initial seed money for experiments like CEPAK, in the long run the introduction of computers on a larger scale into Kenyan schools (or those of most developing countries) will depend largely on the availability of local financial resources. Public budget allocation and/or contributions by communities or parents are the major sources of local funds for education. The remainder of this section discusses financial possibilities and issues related to future CEPAK-like projects.

There is evidence that, short of a major up-turn in the economy, the Kenya public budget is unlikely to be a major source of funds for widespread introduction of computers into secondary schools. Makau (1987) shows that, in spite of more than a third of the public civil budget being spent on education, the government grant to maintained secondary schools falls far short of the financial needs of the institutions. For instance, out of 14 maintained secondary schools whose accounts were studied in detail, 12 had accumulated deficits to the tune of more than a quarter of their annual expenditure budgets.

During the study into CEPAK, data obtained from schools R, S, and T confirmed Makau's findings that public schools were experiencing severe financial constraints. The head at school R, attributing increased expenditure to the introduction of the 8-4-4 curriculum, estimated that in 1988 the school spent the equivalent of US $11,640 (as opposed to $5,820 in 1987) on stationery alone. If accurate, this claim would constitute a major problem when it is borne in mind that, according to the 1980 grant rules (still current in 1988), the 1988 government grant to school R for all learning resources was about $10,000. Evidence of financial constraints at the school was provided by several teachers, the storekeeper and the librarian. In an interview in June 1988, the storekeeper said that since the beginning of the year, only 24 reference books for teachers had been purchased. In response to a question on the acquisition of new library books, the librarian said:

> I never get new books. There is no money for new books. I live in an archive!

With reference to school R, the PD's Quarterly Summary for July - September 1988 stated that in considering the future of the innovation, "it is necessary to carefully consider financial problems with this

school." A similar situation was observed to be the case in school S. Over a week of interviews and observations in June 1988, the following remarks were made by members of the staff:

> School Head said, "Schools are facing big problems. We have already received 6 lawyers' letters from suppliers regarding unpaid bills." On being asked about the library, she laughed and said, "Library! That is a totally dead thing. It is just not possible to buy books for the library. We get a few donations and try to buy reference books for the teachers, but no more than that. Money is that tight!"
>
> The librarian said that the current annual allocation to the library was $582 "which will not buy many new books these days."
>
> A SMC said that the school had a problem in getting books from the usual supplier "as we have not paid previous bills."
>
> Head of Chemistry said, "Lab equipment is not enough, now that more students are doing chemistry because of the 8-4-4 curriculum. The money available is not enough to purchase the equipment needed, especially glassware, where the supply is affected by breakages."
>
> A Physics teacher said, "There is a problem of equipment in the lab. The equipment was initially meant for 10 to 15 students. Now you have 120 doing physics, so there is not enough."

Thus, it would appear that secondary schools, whose financial position is similar to that observed in school R and S, would not have the resources necessary for the introduction of computers.

In contrast to the foregoing, schools P, Q and U demonstrated that it was possible for non-government sources to be mobilised to raise the financial resources necessary for the introduction of computers. School P, largely through the efforts of its eminent chairman of the board of governors, had not only managed to acquire additional computer hardware but also was observed to be ably coping with CEPAK's in-school costs. Interviews with the head and his staff revealed that the school had no financial constraints similar to those found in R, S and T. For instance, in school P the school library was noted to be well-stocked with books. Several teachers said that there were no problems in obtaining textbooks and reference books. Thus, it was not surprising for the management staff to express the opinion that the project had not appreciably resulted in increased expenditure on electricity or stationery. The school would appear to have imperceptibly cushioned the additional expenditure arising from the project. To a lesser extent school Q and U exhibited similar characteristics. As pointed out in Part 3, school U had used its own resources to acquire three computers for use in the management of the school. Interviews with the school head, the SMC and the bursar indicated that the institution had accepted the

innovation as a permanent feature and was prepared to include it in its long-term financial planning. Interviews with the head and staff at school Q indicated that, while there was some concern over financial resources for learning materials, given the affluent community umbrella under which the school was managed, there was a degree of faith that the computer innovation could be financed beyond donor funding.

Schools P, Q and U could be regarded as representative of a small proportion of Kenyan public and private secondary schools which, because they have support from affluent sections of society, are well provided for. Some of the non-project schools in this category have been noted to have acquired computers. It is reasonable to assume that others will follow suit. The fact that some schools are able to mobilise the financial resources necessary for the introduction of computers provides Kenya with an opportunity to experiment with a technology whose role in the society is likely to be increasingly important. Bearing in mind the potential of the computer in the development of (1) a more relevant and efficient education system (2) the economy at the macro-level, a country like Kenya cannot afford to ignore the advances other countries are making towards integrating the technology into school systems.

For the foreseeable future, the great majority of Kenyan secondary schools will remain ordinary and thus unable to count on the parental and community support necessary for the introduction and maintenance of computer technology. Data obtained from schools S and T should shed more light on this point.

Makau (1987) estimated that "in 1985 a family spent about Ksh 6,500 (US $361) in educating one child in a low-cost government maintained (secondary) boarding school."[2] Scrutiny of the 1988 fees in school S (low-cost boarding) revealed that parental expenses for educating one child had risen to the equivalent of $430. With a GNP per capita of less than $400, Makau's conclusion that most parents could not afford higher secondary school fees is more than upheld.

The relationship between financial constraint in schools S and T and the project was indicated by their response to a proposal that, at the expiry of Phase II each school should raise funds so that the innovation would continue. In a February 1988 meeting between AKES (Kenya) and the heads, the PD stated that the project's annual expenditure per school was about $10,650, broken down as follows:

	US $
Consumables	1,164
Insurance	873
Overseas purchases	2,910
Central running costs	2,328

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2. Makau, B.M. The Management and Financing of Secondary Education in Kenya - The Effectiveness of Policy at the School Level. University of Nairobi: IDS, p. 53, 1987.

Training expenses	2,328
Maintenance	1,047
Total	**10,650**

In response to this figure, the head of School T said, "My school cannot afford 200,000 shillings just to run one programme in the school." The deputy head at School R stated, "That is money that would have to come from parents who are already over-burdened." By the end of the meeting, it had been agreed that, with judicious cuts, the innovation could be run with a per school contribution of about $4,074. In an interview in March 1988, the head of School T insisted that the reduced contribution was still too much for his school's Parents and Teachers Association (PTA) to raise; he stated:

> You cannot go round a PTA meeting talking about 70,000 shillings for just five machines which are not even used by everybody.

In June the head of school S expressed similar views as follows:

> We badly need an overhead projector and a video recorder, and I am almost afraid to ask the PTA. If the computers are to be run by the school they cannot be financed by the PTA who are heavily committed to a building programme and they just would not accept the costs of the computers as a recurrent expenditure. Help from the ministry would be essential.

Given the foregoing discussion, the inevitable conclusion seems to be that, on the basis of lack of resources the computer innovation could not immediately be considered for extension to the majority of secondary schools in Kenya. However, even in those schools where financial resources for the introduction of the technology could be made available, monetary opportunity costs would need to be taken into account. These opportunity costs are discussed in the next section.

MONETARY OPPORTUNITY COSTS OF INVESTING IN COMPUTERS AS AN EDUCATIONAL RESOURCE

Referring to opportunity cost as a "sacrifice cost", Coombs & Hallak (1987) explain the underlying logic as follows:

> ...since any nation (or community or individual) has only a limited supply of economic resources to use in any given period, a decision to use some of them for a specific purpose, such as education, means sacrificing the opportunity to spend these same resources on something else.[3]

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3. Coombs, P.H. & Hallak, J. Cost Analysis in Education - A Tool for Policy and Planning. Baltimore: Johns Hopkins University Press Baltimore, p. 13, 1987.

In the section on the potential for replication of the computer innovation, it was indicated that for a small number of Kenyan secondary schools it would be possible to mobilise the financial resources necessary for the acquisition of computer technology for use in teaching and learning. However, the question remains as to whether it would be more cost-effective to purchase computer technology rather than invest the money in teacher education and acquisition of more traditional learning materials, such as textbooks and science equipment.

An attempt was made to indicate the sort of issues which should be addressed in a feasibility study on the desirability of computerising schools. A sample of CAL programs in CEPAK was reviewed with the aim of ascertaining the extent to which, in terms of syllabus coverage and the costs involved, the programs were suitable for the Kenyan secondary curriculum. The sample consisted of 43 programs selected by subjects as follows: mathematics - 9, biology - 11, chemistry - 5, geography - 6, history - 4, economics and business education - 5, and languages - 3. Table 5.05 summarises the particulars of 13 of the programs which were adjudged as good.

An important aspect of the data in Table 5.04 is the fact that, at considerable cost, the 13 programs cover very small proportions of the Kenya secondary syllabuses. The nature of the cost-effectiveness issue involved is revealed by the case of two of the "good" mathematics

Table 5.05. Particulars of a Representative Sample of Programs.

Title of Program	% of Syllabus Covered	Cost US $
Mathematics:		
1. Graphing Equations	3	59
2. Geometric Presupposer	2	59
3. Trigonometric Functions	1	50
Biology:		
4. Biology Pack 2 (natural selection, genetic drift, & and evolution)	1	48
5. Limiting Factors in Photosynthesis	1	16
Chemistry:		
6. Manufacture of Sulphuric Acid	1	24
7. Gas Laws	1	18
Geography:		
8. Water on Land	1	21
9. Hill Railway (map reading)	1	30
10. Poptran (population dynamics)	3	300
History:		
11. Palestine 1947	1	30
Economics/Business Education:		
12. Balance of Payments	1	30
Languages:		
13. Branching Story (creative writing)	5	35

programs in Table 5.0, i.e. **Graphic Equations** and **Geometric Presupposer**. The combined cost of the two programs, which cover only 5% of the syllabus, is $158. In contrast, the cost of 40 copies of the recommended mathematics textbook, which covers the whole syllabus for any one of the four years of secondary school, is about $168. It would appear that investing in CAL software is much more expensive than investing in textbooks. A further ramification of investing in CAL software is the fact that changes in computer technology (including software development) are taking place so rapidly that it is doubtful whether schools - even in the developed North - have the resources to regularly purchase the newest products. In contrast, if a school invests in a set of new textbooks there is a good chance that the books will be in use for a number of years and thus the benefits of investments will be maximised.

Review of the 43 programs and other software examined or observed in use by teachers and students, revealed that many of the programs in CEPAK were trivial and in fact covered topics no more effectively than a textbook or would be the case where the teacher presented facts on the chalkboard. The problem of trivial educational software is not confined to CEPAK. However, in a country characterised by constraints in financing its education system, investment in such software must be called to stern questioning.

What the foregoing discussion suggests is that, in contemplating the introduction of computers as a learning resource, it is essential to institute a carefully planned process of deciding which software must be obtained and how it is best obtained. As opposed to acquiring a large number of imported subject-specific programs, it might be more cost-effective to purchase a limited number of general application software, such as a wordprocessor, a spreadsheet and a database. General applications software has the advantage that it can be used as a tool in school management, an aid in the production of teaching-learning materials, as well as a resource in the teaching and learning of school subjects.

Whereas imported general application software can easily be adopted for local use, in contrast (as per discussion in Part 4), subject-specific software developed from outside is problematic. Thus, there is a strong case for countries like Kenya to conceptualise the production of local educational software as an important part of the introduction of computers as a learning resource. In order to economise on costs and to avoid the time constraints (discussed in Part 4) associated with teachers' efforts to learn computer programming, the development of local educational software should be undertaken centrally by the designated curriculum body. This approach should have the distinct advantage that the software is developed as part of the overall production of curriculum materials.

In Part 6, an overview of the discussion in Parts 1 to 5 is presented. The outcomes of the innovation are discussed in relation to six basic factors, namely (1) functionality of computer managed education (2) student response to the innovation as confirmation of preference for learning as a natural process (3) the status of the computer as an

educational technology in Kenya (4) the level of funding, particularly as it affected student to computer and staff to computer ratios (5) ways in which the school system influenced the innovation (6) effects of the size of the implementation team and the strategy employed in the staff education component.

PART 6

BASIC FACTORS INFLUENCING THE INNOVATION - AN OVERVIEW

INTRODUCTION

Through discussion of a number of basic factors which influenced the innovation, Part 6 attempts to draw together the main aspects discussed in the first five parts. The aim of such synthesis is to place the innovation in a wider context in relation to (1) the acceptability of the computer as a school resource (2) student preference for learning as a natural process (3) constraints which were imposed on innovation by the social setting, limited funding, hierarchy and authority in the school system, and implementation approaches which did not fully take account of the reality in schools.

COMPUTER MANAGED EDUCATION - DEMONSTRABLE COMPARATIVE ADVANTAGE

As per discussion in Part 3, the implementation of the innovation achieved considerable success in the spheres of school management, monitoring students' academic progress and the production of teaching and learning materials. This success is explainable on two counts. First, the three spheres were already part of the schools' responsibilities. Thus, the introduction of the new technology was not visualised by the staff as requiring them to venture into a completely new area. For example, documents produced on the wordprocessor were not seen as different from other print media which students and staff were already familiar with. Second, school staff were able to recognise that there were advantages in using the computer. For instance, because the wordprocessor reduced the drudgery in the production, correction and updating of documents, it was recognised as being superior to the ordinary typewriter. Similarly, the potential of (1) the spreadsheet in financial accounting and manipulation of academic data (2) the database in managing students' and teachers' personal data was recognised as faster and more accurate than manual handling.

The main lesson to be drawn from CEPAK's success in the area of computer managed education is that schools will embrace computer technology if they, with minimum disruption of existing work patterns, can identify areas in which its use has clear comparative advantages over other technologies.

STUDENTS' RESPONSES TO THE INNOVATION - PREFERENCE FOR LEARNING AS A NATURAL PROCESS

In spite of limitations in students'access to the technology and gender-based inequality associated with the innovation, the majority of students

were excited by the introduction of the computers into their schools. In all schools most students were eager to get an opportunity to work with the technology either as part of formal class work or out-of- class activities.

As indicated by students' interest in such spheres as computer programming and wordprocessing, students were not lost to societal perceptions that exposure to the technology could maximise their manoeuvre in the job market at a future date. In the 1988 survey, in each case more than two thirds of the sample were of the opinion that exposure to computers would give them an edge in obtaining jobs in accounting, commerce and industry, and engineering. However, student interest in the technology went beyond belief that exposure at school was relevant preparation for future career.

The students' fascination with the computer (in particular playing games) was a reflection of the captivating nature of the technology and an indication of the students' preference for the natural learning process in which the cognitive, affective and psycho-motor are interwovenly involved. Peer learning, individualised learning and control of the pace of learning, which the innovation encouraged, were appreciated by students as part of the natural learning process.

There is evidence that the students' preference for the natural learning process is deeply embedded in the human personality and that, rather than causing it, the computer innovation only provided it with an opportunity to manifest itself. In the baseline survey, students were asked to rate eight learning strategies in terms of the extent of "understanding" and "enjoyment". The responses on "understanding" and "enjoyment" were correlated. The coefficients of correlation in five of the learning strategies are shown in Table 6.01.

It is significant that the positive correlation between understanding and enjoyment increases as the learning strategies become more learner-centred. The highest coefficient of correlation is reported for a learning strategy which involves the student in active exploration.

Table 6.01. Correlation Between Understanding and Enjoyment in Five Learning Strategies.

N = 5 Schools (1,535 students)

Learning Strategy	Coefficient of Correlation	Nature of Activity
Listening to teacher (lecture)	.4776	Listening
Writing teacher's notes	.5870	Copying
Answering teacher's questions	.6450	Answering
Exchanging views with teacher	.6580	Discussing
Working with apparatus	.7964	Active exploration

The data in Table 6.01 which point to the student's preference for learning situations which excite and make him active and autonomous, confirm the findings, common in the literature on current learning theories, that learning is an innate, active, constructive and goal oriented process in which every individual is involved and in which the cognitive and emotive parts of the human brain are engaged in a complementary manner (Piaget 1955, Mueller 1974, Wittrock 1974, Anderson 1983, Dale 1985, Hemming 1986, Larsen 1986, Shuell 1986, Pratt 1987, Boder 1989). In contrast to the behavioural orientation which focuses on behavioural changes requiring a predominantly passive response from the learner to various environmental factors, Shuell (1986) points to the cognitive psychology view, which dominates current learning theory, that the learner is actively involved in three mental activities: (1) metacognitive processes such as planning and setting goals (2) active selection of functional, as opposed to nominal, stimuli (3) attempting to organise the material being learned even when the material has no obvious basis of organisation. This view maintains that learning is based on the individual's mental schemata (organised, structured and abstract bodies of information) of what the learner already knows and which he brings to bear on learning new material, and that three hierarchical psychological processes are involved in learning the new material: (1) selective encoding - sifting relevant information from the irrelevant in the stimulus environment (2) selective combination - integrating selected information in a meaningful way (3) selective comparison - integrating newly encoded information with information already stored, resulting in the development of new schemata.

Complementarity of the cognitive and affective parts of the brain is both argued to be real and as constituting the linch-pin in meaningful learning. By way of proof of the reality of complementarity, Yarlot (1986) states:

> It simply does not make sense to speak of the left hemisphere (of the brain) taking the literal meaning, and the right hemisphere the emotional tone, when, in interpreting a work of literature, verbal and emotional operations take place, surely as a single, simultaneous and virtually indivisible process.[1]

Larsen (1986) refers to a study in which it took a class less time to learn poetry than was the case with regard to prose of similar length because "the passages on poetry possibly activate memory functions of a non-semantic character more frequently than do prose passages, and thus relate the content more directly to imagination and recollection of prior experiences of the learner."[2] In arguing that the primary needs of the

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1. Yarlot, G. Split-Brain Theory and Education. British Journal of Educational Studies 34.3, p. 24, 1986.

2. Larsen, S. Information can be transmitted but knowledge must be induced. Programmed Learning and Educational Technology 23.4, p. 333, 1986.

learner are for growth and self-actualization, "being needs" for all individuals, Pratt (1987) maintains that curricula conceptualisation should take into account that "psychological and social health depends on recognition and integration of the many different aspects of being, including the cognitive, the affective, the social, the somatic and aesthetic. These include not only areas of objective knowledge, but also areas which are irreducibly subjective, such as the spiritual."[3] In advocating learning experiences closely related to the whole environment, Hemming (1986) sees complementarity of the cognitive and affective as enabling the individual to make his or her brain:

> We are far from understanding the details of how the brain is laid down and wired up, but it is beginning to look as if, to a considerable extent, we make our own brains by the way we interact with the world and subjectively evaluate the experiences we generate. The richer our relationships with the world, the more complex our brains become.[4]

Two crucial points are made in the foregoing summary of learning theory. First, the child naturally learns by using his or her existing knowledge to interpret and incorporate new knowledge. This process is cumulative: through incorporation of new knowledge, the child creates a new and more sophisticated base for interpreting and incorporating further new knowledge. Second, natural learning involves the whole personality of the child. The child's feelings (the affective) and psychomotor work in concert with the rational brain (the cognitive) in the process of interpreting and incorporating new knowledge.[5] In relation to the computer innovation, activities which approximated natural learning - such as computer-assisted lessons which were based on the child's knowledge of and excitement about the environment, or computer games which enabled the child to experience pleasure as he or she learned - were embraced by the students because they played a sweet melody on a key chord in the human personality. In contrast, where activities at the computer were artificial and unnatural - e.g. in relation to passiveness and boredom when not on the keyboard, or lectures about the role of IT in society, or viewing CAL programs beyond the current knowledge of the learner - the students were ambivalent or even rebellious in their response.

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3. Pratt, D. Curriculum Design as a Humanistic Technology. Journal of Curriculum Studies 19.2, p. 55, 1987.

4. Hemming, J. Personal Motivation: The Key to Effective Education. New Era - Journal of the World Education Fellowship 67.3, pp. 59-60, 1986.

5. The two interpretations of learning theory should give meaning to such phrases as "the child's readiness for learning" and the "importance of organising learning such that the learner moves from the known to the unknown."

Modern cognitive theories of learning do not dismiss the importance of the learner's response to the environment. On the contrary, these theories recognise that the entire environment - including the home, school and social setting - constitute the source of new knowledge which the learner naturally strives to interpret and incorporate. In this sense, thinking along the line that the computer could make the student completely independent of the teacher is unnatural and unrealistic. Thus, it was natural for most students to feel that the benefits of the computer innovation would be maximised if the teachers fully participated in technology-based learning activities. In contrast, the tendency by most teachers to play a passive role in computer-assisted lessons would seem to indicate that the teachers either (1) did not fully understand their students' need for them, or (2) they did not regard the lessons as important in the whole learning scheme.

Students in the six schools were very much aware that the environment from which they drew new knowledge was dominated by parental and societal expectations of youth. These expectations were to a large extent manifested through planned curricula, the learning of which was formally certificated according to performance in regular public examinations. This planned scheme of learning was recognised by students as focusing learning such that a given body of knowledge had to be acquired. For reasons discussed in a later section, the acquisition of this body of knowledge was regarded by the majority of students as a process in which the teacher played a central role. In the baseline survey, students were asked to indicate their their preferences for three types of teachers. An analysis of the students' responses is shown in Table 6.02.

It is clear from the data in Table 6.02 that most students preferred the teacher who gave them all the facts. As the teacher's task becomes more and more that of a facilitator of learning rather than the source of knowledge, the proportions of students who regarded the teacher as very

Table 6.02. Students' Rating of Three Types of Teachers.

N = 5 Schools (1,535 students)

	Percentages of Students					
	Very Helpful 1	2	3	4	Not Helpful 5	No Data
The teacher who:						
(1) tells you all the facts	54	22	9	6	4	5
(2) encourages you to collect real things	49	26	14	4	2	5
(3) encourages you to obtain new knowledge on your own	38	18	16	11	12	5

helpful drops. Preference for the teacher as principally a source of knowledge was closely associated with the students' perceptions of how teaching and learning of the examination-driven curriculum should take place. In the 1988 survey, in relation to preparation for public examinations, students were asked to compare use of the new technology and two traditional sources of knowledge. An analysis of the students' responses is shown in Table 6.03.

The data in Table 6.03 show that overall the majority of students were not enthusiastic about the view that use of the computer prepared them for examinations better than the teacher or the textbook. The proportions of students who strongly agreed with the three statements were much lower in school U, where students had received most exposure to the computer as an educational resource. It would appear that, in comparison with the other five schools, in school U the longer exposure to the technology had given the students a more realistic opportunity to evaluate the innovation's centrality in a major objective of secondary school learning.

For school U, the responses to the statements in Table 6.03 were analysed by class. In Table 6.04 the responses to the three statements in Table 6.03 are juxtaposed to responses to a fourth statement.

Of the five classes in Table 6.04, Form 6 was the only class entered for a public examination at the end of 1988. The data in the table show a trend according to which, as classes moved closer to the public examination the proportions of students who regarded the computer as an aid central to preparation for certification decreased. In this sense, the responses to the fourth statement are telling: as compared to no more than 1% in the classes not immediately faced by the examination, 13% of Form 6 students strongly agreed that involvement with the computer took time away from acquisition of the body of knowledge required for certification. Students were asked to respond to four other statements which, while not mentioning public examinations, elicited for attitudes towards integration of the technology into the curriculum. The responses, analysed by class, are shown in Table 6.05.

Table 6.03. Percentages of Students Strongly Agreeing With Given Statements on Preparation for Examinations.

	P	Q	R	S	T	U	Total
The computer:							
- is better for revision for exams than the teacher	24	28	32	31	29	10	25
- programs prepare you for exams better than textbooks	19	29	28	25	24	9	22
- prepares you for exams better than the teacher	13	19	23	21	21	7	16

Table 6.04. School U Students Strongly Agreeing With Given Statements on Preparation for Examinations.

	%s of Students				
	F1	F2	F3	F5	F6
The computer:					
- prepares you for exams better than the teacher	11	9	5	6	1
- is better for revision for exams than the teacher	11	13	9	10	8
- programs prepare you for exams better than textbooks	14	14	3	10	1
- takes time away from preparing for exams	0	1	1	1	13

Note: F = Form. Because in 1988 the earlier system of education was in the process of being replaced by the 8-4-4 system, there was not Form 4 in Kenyan secondary schools.

Table 6.05. School U Students Strongly Agreeing With Given Statements on Use of Computers in Lessons.

	%s of Students				
	F1	F2	F3	F5	F6
The computers do things which are not on the syllabus	9	7	19	16	33
Using computers takes time away from your studies	4	6	0	12	16
Learning with computers is best for revision	44	57	41	41	25
You learn more in computer lessons than in ordinary lessons	22	9	9	13	5

The data in Table 6.05 show that responses to statements which did not mention public examinations had a trend similar to that in Table 6.04. Thus, it is implicit in the data in Table 6.05 that as students moved towards the end of the secondary school course, they increasingly associated terms such as "syllabus", "studies", "revision" and "lessons" with preparation for the publication examination. In relation to the computer innovation, as classes moved closer to the end of the secondary course, increasingly higher proportions of students lost faith in the centrality of the computer as a learning resource. For instance (1) while less than one tenth of Form 1 students strongly agreed that the computer innovation was irrelevant to the syllabus, a third of Form 6 students strongly espoused this view (2) while 22% of Form 1 students

strongly felt that, as compared to the ordinary lesson, a computer-assisted lesson was a richer source of knowledge, only 5% of Form 6 students strongly concurred.

The foregoing discussion suggests that as students approach the public examination they become less willing to embrace innovative learning approaches, particularly if the new approaches are open-ended and thus not overtly geared to the acquisition of knowledge of prescribed content. However, although this finding may to a large extent be valid, it does not provide a full explanation of the CEPAK students' responses to the computer innovation. The students' responses were not reactions to a scientific experiment in which hypotheses on innovative learning were tested while variables likely to interfere with the experiment were controlled for. In CEPAK the reality of the implementation included such variables as the nature of the technology, level of funding, non-monetary costs, the peculiarities of each school and the school system. The students' responses to the innovation were manifestations of the interrelationships between the variables involved in the implementation and the students' personal characteristics.

THE COMPUTERS AS AN EDUCATIONAL TECHNOLOGY IN KENYA

During the later 1980s, that is the period during which Phase II of CEPAK was in operation, the microcomputer was a new technology in Kenya. As shown in Part 2, few of the staff and students in the project schools had prior exposure to computers. In the society as a whole, the great majority of the population did not use computers and was probably unaware of their existence. Thus, in a very real sense the project schools were venturing into an area where, in their efforts to master the new technology, staff and students could expect little by way concrete support from the society. To illustrate this point, let us consider a parallel in farming. Introducing the computer was not at par with learning how to use a new piece of agricultural machinery to maximise coffee production. Integration of new machinery into coffee farming would have benefited from the widespread local experience and knowledge in this area.

The novelty of the technology had a positive side to it. The opportunity to work with a computer excited most students and some teachers. Building on existing vague notions that the technology was the key to success in the future, the computer motivated those who took at interest in a manner no other learning resource could. In earlier parts of the report several examples of students and staff spending most of their free time in the computer room were highlighted. The examples of imaginative and highly motivating computer-assisted lessons indicate that, with longer relevant exposure, the technology could play a major role in the development of more child-centred teaching and learning approaches.

On the negative side, lack of previous exposure and the scarcity of concrete support from the society had the effect of increasing anxiety and fear of the technology. Lack of previous exposure engendered beliefs

that the technology was expensive, delicate and could be the cause of fatal accidents.

An important feature of the newness of the computer was that it is very different from other educational technologies, such as radio, television, chalkboard and textbooks. It is relatively easy to learn how to functionally work with these technologies. In contrast, as shown in Part 4, before the user can functionally apply it, the computer requires mastery of several intricate technical processes. In the case of the six schools, mastery of the computer was hampered by the fact that most staff and students were unfamiliar with the ordinary typewriter keyboard.

The absence of widespread knowledge and experience of computers in Kenya can partly be explained by the fact no local computer industry had been developed. In Part 4, it was pointed out that because the technology had been imported into Kenya, a number of hitches had arisen with regard to acquisition and maintenance of the equipment. The absence of an indigenous computer industry also explains the fact that there were no local commercial software development ventures from which CEPAK could obtain educational software. Thus, as explained in Part 4 most software in the project was imported. The necessity of having to import software placed severe limitations on the type and number of software provided by the project. Cultural bias in software manifests itself most clearly in the humanities and languages because the content of the programs is naturally specific to the curricula of the country of origin. Although cultural bias does exist in mathematics and science software, a considerable amount of content in these disciplines is universal and is therefore part of the curricula of several countries.

Because of the foregoing considerations, most of the subject- specific software imported by CEPAK was in the sciences and mathematics. As explained in Part 4, this preponderance in software provision had ramifications in the gender inequality associated with the innovation, and adversely affected the attitudes of language and humanities teachers towards the innovation. It is also possible that the apparent imbalance in available software induced students whose major interest was in languages and humanities to believe that the technology was not very useful in their learning.

LEVEL OF FUNDING

Computer to Student Ratios

In Parts 3 and 4 it was indicated that there was intense competition among students for control of the keyboard during learning activities involving computers. An outcome of this competition was to intensify inequity in the learning situation, particularly in the mixed schools. The basic cause of competition was the interplay between the number of computers available and student interest in the technology. Most students were intensely keen on working with the technology, but the number of computers greatly limited the length of time each student could

personally operate the keyboard. Taking into account the additional hardware purchased by school P, the six schools had the following computer to students ratios: P - 1:35, Q - 1:84, R - 1:152, S - 1:100, T - 1:88, U - 1:44. Assuming that during all formal lessons all students had a chance to personally operate a computer, in one week each student would have had the following number of minutes on the keyboard: R - 12, S - 18, T - 20, Q - 21, U - 41, P - 51. In the 39 weeks during which schools were in session, the time each student would have been on the keyboard ranged from 7.8 hours in school R to 33 hours in school P. As per discussion in Parts 3 and 4, during Phase II: (a) most formal lessons did not involve use of computers (b) at least one computer was reserved for school management tasks or for use by teachers (c) on occasion the hardware was out of order.

On the basis of the foregoing, it is obvious that the time available for all students to personally work with the technology was extremely limited. Thus, it may well be the case that this limitation contributed to the attitude among students that the technology was not central to their learning.

Computer to Teacher Ratios

Although the teacher to computer ratios were much lower than was the case for students, not all teachers who wished to use the technology could do so at will. For instance, a teacher who wished to use a computer to produce a handout faced a number of limitations. The teacher could only work on the handout during a free period. The teacher's free period might coincide with a computer-assisted lesson; alternatively, all computers might be occupied by other teachers. The time dimension implicit in the foregoing might be compounded by a host of other issues such as: limited skill in operating the computer, unavailability of stationery because the SMC is absent, malfunctioning of the equipment or interruption in power supply. Thus, as was the case with the students, among the staff there was an element of competition for limited resources. To an extent, for some teachers unwillingness to get embroiled in this competition may have contributed to reluctance to get involved in the innovation.

THE SCHOOL SYSTEM AND THE INNOVATION

Aspects of Success Among the Early Adoptors

As per discussion in Part 3, in each of the schools a proportion of staff took interest in the innovation. Among these adopters of the technology new pedagogical perceptions began to emerge. A few of the teachers made imaginative attempts to integrate the new perceptions into teaching-learning activities. Although the number of teachers adopting new approaches was small, the very emergence of a core of interested staff must be regarded as a major achievement of the innovation. Given time, this core of teachers could considerably influence some of the other members of staff as well as the senior management of the school. A

teacher who is able to use the computer to make learning an exciting process for students and, at the same time, be able to guide them to good performance in the public examination, will not fail to attract the attention of colleagues and the management of the school. The same could be said about a teacher who is able to functionally demonstrate that use of the computer has comparative advantage over manual methods in an aspect of school management. It was observed that SMCs and other teachers who undertook albeit limited computer analysis of examination data, or prepared management documents on behalf of the heads were highly valued members of the staff. In one case the school authorities were so impressed by the input of one of its SMCs that a scholarship was organised for him to go for further formal study in computers and education. In another school, the head fought hard to retain an SMC who had been threatened with transfer to a non-project school.

Personal Goals Among the Early Adoptors

Obviously the provision of the technology and the implementation efforts made played a major role in the emergence of a core of teachers willing to use the computer. However, other factors played a role. First, prior exposure to computers had prepared some of the teachers to readily accept the innovation. In all schools, most early adoptors of the innovation were teachers with prior experience with the computer. Second, as was the case with the head at school U at the launching of Phase II, earlier involvement in educational innovations had prepared some staff for acceptance of the computer. The same was also true of teachers who were already practising learner-centred approaches. Third, some members of staff in the schools were able to immediately identify personal goals as reasons for adoption of the innovation. Such goals included the possibilities of using the computer to author books and the acquisition of knowledge enabling a teacher to change career. It was observed that in the course of Phase II, at least four teachers left school teaching to take up computer-related jobs elsewhere.

School Management Ambivalence to the Innovation

While because of personal dispositions a number of individual teachers embraced the technology, there were clear indications that the schools were ambivalent in their responses to the technology. In all schools, the innovation was accepted by senior management as a useful tool in administration and the production of teaching and learning materials. The schools were keenly aware that the innovation had considerable public relations potential. For instance, computer produced documents and banners, and demonstrations of aspects of the technology were observed to be regular features in relation to open day activities. In one school the computers were exhibited in the school's stand at the local annual trade fair.

In schools Q and U, where large proportions of student enrolments had parents or guardians with a fare awareness of the potential of the computer in the work-place, the schools felt duty bound to bow to community expectations and thus instituted formal IT and/or computer

studies courses. In the other four schools there was some acceptance that it would be useful for the future if students were exposed to an IT type of learning activity. However, the four schools attempted to give such exposure as part of out-of-class activities, i.e. as something less important than formal lessons.

With regard to the integration of the technology into the teaching and learning of the older curriculum, school management was at best lukewarm. In a meeting (November 1987) between representatives of the funding agency and the heads, the latter clearly stated the potential of computers in school management and production of materials by teachers, but were vague on exposing students to the technology and use of the computers in lessons. With the exception of the short-lived attempt at school T in early 1987, none of the schools articulated a policy requiring teachers to use the technology in lessons related to the normal curriculum. As shown in Part 3, some teachers did use the technology in such lessons. However, such use was through the teacher's own choice. Although the project proposal had advocated an approach which allowed the individual teacher to choose when to start using the computers in lessons, the expectation was that the number of users and the frequency of use in various subjects would increase as the implementation proceeded. With the exception of school U, observations at the schools did not reveal any increase. On the contrary, as indicated by a decline in the borrowing of software from the project library, the number of teachers who undertook in-school review and use of software decreased between 1987 and 1988. Table 6.06 shows the number of times various categories of programs were borrowed by schools between January 1987 and 16 February 1989.

The data in Table 6.06 show that subject-specific programs were borrowed more frequently than any other software. The frequency of borrowing in this category decreased by more than 50% between 1987 and 1988. In Table 6.07, the frequency of program borrowing is analysed by school.

Table 6.06. Number of Times Programs Were Borrowed by Schools, 1987 - 1989.

	1987		1988		1989	
Category of Programs	n	%	n	%	n	%
Subject-specific	194	80	93	84	21	78
Graphics	19	8	13	12	1	4
Educational games	15	6	2	2	3	11
General applications	9	4	2	2	2	7
Utilities	3	1	1	1	0	0
General education	2	1	0	0	0	0
Total	242	100	111	101	27	100

Table 6.07. Frequency of Program Borrowing by School.

School	1987		1988		1989		Total	
	n	%	n	%	n	%	n	%
S	93	38	19	17	0	0	112	29
R	56	23	34	31	0	0	90	24
P	16	7	18	16	25	93	59	15
Q	34	14	15	14	0	0	49	13
U	21	9	24	22	0	0	45	12
T	22	9	1	1	2	7	25	7
Total	242	100	111	101	27	100	380	100

Note: Since school had its own well-equipped software library, it was much less dependent on the project library.

The data in Table 6.07 not only indicates in which schools the decline in borrowing was most severe, but also the inter-school differences in the use of the central library. School U should be treated as a special case because it had its well-equipped library. With regard to the other five schools, the data reveals three trends. First, school T accounted for only 7% of all borrowing in the period under discussion. Second, in terms of the actual number of borrowings, schools S, R and Q used the library less and less between 1 January 1987 and 16 February 1989. Third, over the same period school P registered an upward trend in the use of the library; for instance, this school accounted for 93% of all borrowing in early 1989. These three trends corroborate data obtained through interviews and observations. At the initial stages of Phase II, in each school a few individual teachers were excited by the technology and took the trouble to borrow software and find out more about the innovation. However, school management remained distanced from these individual efforts. Thus, as the novelty of the computer wore off and as the individuals discovered that integration of the technology into the curriculum is not without problems, teachers' interest in borrowing software declined. The case of school P is an interesting one. Towards the end of 1988 a new SMC with a masters degree in computer science was appointed. He generated considerable enthusiasm among some of the science and mathematics staff. This enthusiasm largely explains the fact that in less than two months, the school borrowed more software than had been the case in either 1987 or 1988. However, it was observed that the increase in borrowing of software did not result in the use of the technology in formal lessons.

The unwillingness of senior management in the schools to make and implement policy in relation to the integration of the technology into the curriculum can, to an extent, be explained by the fact that, apart from the heads of two of the schools, most senior members of staff did not take to personally using the computers. It could thus not be ruled out that most senior teachers, blinded by ignorance of and anxiety over

the technology, did not readily appreciate the pedagogical ideas of the innovation. However, other data suggest that senior management ambivalence to the innovation resulted much more from perceptions of constraints imposed by the education system as a whole.

In a heads' project workshop in which the desirability of curriculum development at the school level was discussed, several participants were cynical about the suggestion, with one of the heads summing up others' views as follows:

> Curriculum development is the responsibility of the Kenya Institute of Education. We have strict instructions from the education inspectorate to follow the specified order of curriculum content coverage.

Authority and Hierarchy in the School System

The heads' reaction to curriculum development at the school level was typical of the attitude of senior staff that schools were not in a position to engage in innovative approaches which apparently were not part of the curriculum mandated by the Ministry of Education (ME). As the study into Phase II proceeded evidence mounted to the effect that the model of school, which Kenya shared with other countries and was to a large extent imposed by society (Buckman 1973, Bowles & Gintis 1976, Giroux 1983, Keesbury 1984, Apple & Teitelbaum 1986, Shor 1986, Cuttance 1987, Edelstein 1987, Tornvall 1987), was not fertile ground for the germination of innovative educational ideas, such as CEPAK was attempting to plant. The school was perceived as an instrument for the mass acculturation of youth, with the main features of the process being the implementation of centralised curriculum and certification based on performance in content-specific state-wide examinations. In order to achieve the perceived objective, the Kenya school system had been developed as an orderly and authoritative institution characterised by a hierarchical organisation. The head received the curriculum and instructions from ME, he or she in turn was looked upon as the source of authority by the teachers and at the bottom of the ladder, the students were expected to receive knowledge from the teachers. This authoritarian and hierarchical organisation influenced school management and teachers' perceptions of their roles and adversely affected learning as a natural process.

In the baseline survey 51% of the teachers indicated that the status of school teachers in Kenya is low. In common with other countries, the low status of the teaching profession is partly explained by the role society prescribes for teachers. Addressing the issue, Piaget (1970) states

> What the schoolteacher lacks, in contrast to (other professionals), is a comparable intellectual prestige. And the reason for this lack is an extraordinary and rather disturbing combination of circumstances. The general reason is, for the most part, that the schoolteacher is not thought of, either by others or, what is worse, by himself, as a specialist from the

> double point of view of techniques and scientific creativeness, but rather as the mere transmitter of a kind of knowledge that is within everyone's grasp.[1]

Observations at project workshops and discussions with staff indicated that both school management and the teachers felt that the innovation did not fall within the realm of the official curriculum. Before the launching of Phase II, the Director of Education had given permission for the innovation to be extended to the four public schools, and this authorisation had been communicated to the schools. In October 1986, the Minister for Education was the guest of honour at the official launching of Phase II, a ceremony attended by the school heads. In spite of these overt indications that the government was in agreement with the ideas of the innovation, there was subtle evidence that some staff in the project schools felt that, rather being mounted for the improvement of the schools and the education system in general, the innovation was an unofficial experiment whose results would be of benefit to unnamed bodies outside the school system. In spite of repeated assurances, on a number of occasions veiled accusations were made that the researchers were really the agents of the unnamed beneficiaries. The PD was sometimes questioned on the exact relationship between the innovation and the official curricular processes. This questioning explicitly surfaced in a recommendation made by the SMCs in a workshop in August 1987. In his report on the workshop the PD recorded the recommendation as follows:

> There...needs to be given to schools a high level statement from the Ministry (of education) that they may experiment, within the 8-4-4 (curriculum) with computer uses, and that these experiments would be accepted by provincial education officers, inspectors, etc., since at present many teachers are fearful of departing from the fairly rigid rules which have been laid down by these groups.

Unable or unwilling to interpret the learner-centred ideas of the innovation, ideas which incidentally were clearly stipulated in the official syllabuses, the schools felt that higher authority needed to be more explicit in guiding them on how to integrate the technology into the national curriculum.

Staff Turnover

An expression of the hierarchical and authoritarian school system was the fact that schools did not have control over the deployment of staff. Even in the two private schools in the project staff tenure, particularly that of the heads, was under the control of community bodies outside the school. During Phase II, partly due to decisions made by higher authorities, there was rapid turnover of teachers in the project schools. For instance, 38% of teachers who responded to the 1988 questionnaire had

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1. Piaget, J. Science of Education and Psychology of the Child. New York: Orion Press, 1970.

arrived in their schools after the project start-up workshops. It was observed that rapid teacher turnover adversely affected the implementation of the innovation in two ways. First, departure of some of the early adoptors of the technology reduced the core of staff on whom the development of the innovation depended. This aspect was observed to be particularly debilitating in school U, where in early 1987 five early adoptors left the staff partly because of an unpopular change in headship. Second, the arrival of a sizeable number of teachers new to the innovation made additional demands on teacher education activities. Successful induction of new arrivals required that special attention be given to them, either in additional workshops or through purposeful grouping in workshops already planned. In Part 4 it was pointed out that, partly because of time constraints, the implementation team did not go out of its way to give special attention to new teachers.

Throughout Phase II headship did not change in schools P, Q, R and S. In school T there was a change in headship at the beginning of 1988. This change interfered with the implementation of the innovation. Without the benefit of experience and training given to his predecessor since mid-1986, the new head was being called upon to guide a professionally delicate innovation midway its implementation. This factor partly explains observations that, relative to the other schools, in school T internal dissemination of the innovation was weak. During 1987 the headship of school U changed four times. These changes were unsettling to the staff and, as pointed in the previous paragraph, at least on one occasion they contributed to the departure of key staff. However, because of its longer exposure to the innovation, school U was able to weather the adverse effects of changes in headship.

Limited Collegial Interaction Among Staff

In Part 4 evidence was presented to show that there was belief among teachers that, relative to other jobs in the modern economy, teacher remuneration was low. This belief and the lowly position of the teacher in the school system had the effect of weakening the management of the learning process in the schools. Particularly important in this respect, was the observation that the subject department system in five of the project schools did not function as an effective vehicle through which professional growth could take place through collegial interaction. During the baseline study, several school heads attributed the weakness of the subject department system to the fact that heads of department received no monetary allowance in relation to the position. Interviews with teachers suggested that in some schools there was a strong feeling that the individuals holding positions as heads of departments had been appointed not because they professionally merited the positions, but because they were the favourites of the school heads. Except in school U where (as shown in Part 3) an attempt had been made to develop the subject departments, it was observed that department heads did no more than undertake a number of administrative chores. There was no evidence that departments undertook to organise regular forums for professional discussion and planning. Such forums would have been ideal for dissemi-

nation of innovations in the learning process, such as CEPAK was seeking to introduce.

At the school level, regular communication of information related to the innovation was a crucial factor in the successful integration of the technology into curriculum. In relation to specified sources, the 1988 questionnaire required teachers to respond to the question, "How do you find out information about the programs available in your subject?" Respondents were prompted to tick against more than one source. The responses of teachers who selected various sources are analysed in Table 6.08.

The data in Table 6.08 show that, apart from school U, heads of departments or colleagues in the same department did not play a major role in disseminating information on subject- specific software. In-school observations revealed that in all the institutions, including school U, there was no discernable departmental commitment to the use of computers in lessons or to the systematic review of software. Thus, in relation to subject departments the assumption that collegial interaction would be a crucial link in the implementation of the innovation amounted to a misreading of the reality in the schools.

Table 6.08. Teachers' Sources of Information on Subject Programs.

	%s of Respondents						
	P	Q	R	S	T	U	Total
Teacher in charge of computers	64	15	30	50	27	76	47
CEPAK program list	32	77	39	50	7	56	38
A subject workshop	14	31	9	25	7	28	18
A teacher in same department	9	0	4	8	7	16	8
Head of department	0	8	0	8	13	48	16
A magazine	5	0	4	8	7	8	6

School Media Co-ordinators and Hierarchy

In a situation where little professional interaction existed between teachers and their heads of departments or colleagues in the same department, it was unlikely that SMCs would be visualised as capable of effectively disseminating the pedagogical ideas advocated in the innovation. For example, teachers in departments different from that of the SMC were bound to feel that he or she did not have the knowledge to give them pedagogical guidance in their subjects. Equally important, because SMCs like heads of departments were perceived as creations of the authoritarian and hierarchical school system, it was unlikely that the rest of the staff would regard SMCs as having the empathy to go out of their way to assist teachers in mastering the technology. For the ordinary teacher, this perception seemed to be justified by some the

actions taken by SMCs. However desirable in terms of security of the equipment and the need to conserve limited resources, such actions as limiting teachers' access to the RC or computer stationery were bound to be interpreted as ill-intentioned and geared to preventing teachers from learning how to use the computers. Thus, it was no surprise that on occasion some SMCs were accused by their colleagues as being empire builders who were using the innovation to make a niche for themselves and ingratiate themselves with the heads and other school authorities.

Examination-Driven Curriculum

The single most important aspect of the school system which interfered with the integration of the new technology into the teaching and learning of the normal school disciplines was the centrally mandated and examination-driven curriculum. In an earlier section, this factor was shown to have exercised a lot of influence on the students' responses to the innovation.

A unique aspect of CEPAK was the fact that its launching coincided with the introduction of the 8-4-4 secondary curriculum, which had drastically recast the content to be learned. The first cohort of students to use the 8-4-4 curriculum was selected to enter secondary school at the beginning of 1986. Phase II was launched later in the same year. Thus, teachers in the project schools were being called upon both to introduce a new curriculum, and to develop teaching-learning approaches based on a new technology. In Part 4 it was shown that the new technology made additional demands on teachers' time, and mental and affective energies. The introduction of the new curriculum compounded these demands on the teacher. Although the new curriculum stipulated objectives which (through development of appropriate cognitive, affective and motor skills) aimed at nurturing growth of the learner's personality and relevantly preparing youth for participation in the wider socio-economic context, in the reality of the teaching-learning transaction the most salient feature of the subject syllabuses was content which could not be covered in the time available (Makau 1985). Teachers were observed to be unsure of the scope of syllabus coverage expected of them or of the depth of knowledge expected of their students at the end of the course. Most teachers interviewed expressed the view that all the time available had to be devoted to the coverage of the lengthy syllabuses. Teacher ambivalence towards the computer innovation was closely related to the anxiety associated with the new curriculum. Teacher anxiety over the new curriculum reflected uncertainty as to what form the all important end of course examination would take.

In spite of well articulated educational objectives and goals, centrally developed curricula and examinations tend to encourage the view that learning is the acquisition of knowledge selected and delivered by the teacher (Somerset 1982, Makau 1985, Apple & Teitelbaum 1986, Doyle 1986, Haywood 1986). Because society holds school staff accountable for students' performance in examinations, teachers seek to control the teaching-learning transaction and to narrow coverage to the syllabus areas which are examined, more often than not, as discrete facts.

Referring to an American school district English course aimed at developing creative writing and appreciation of literature, McNeil (1987) states that the amount of student writing and the time spent in analysing works of literature was found to be limited because

> ...the students would have to take a proficiency test on grammar, spelling, sentence structure and other components of grammar and composition. Since these would be presented on a multiple-choice test at the end of the semester and recorded by the district as part of the teacher evaluation policies of the district, many teachers felt that the first priority was to get their students through the tests.[2]

In Kenya teachers face similar constraints. Society (including parents and students) interpret good performance in the terminal public examination as an indication of a successful secondary education. There is tremendous social and school pressure on teachers to deliver good results and to adapt their teaching styles to the attainment of such results. With regard to the nature of the examination, in many of the test papers good results can be attained through mastery of a sufficiently wide body of factual knowledge. Conscious of regular public teacher-baiting in relation to poor examination results, teachers in the project schools were observed to be unanimous that equipping students with the facts required in the public examination was top priority. Child-centred learning which is geared to the development of problem-solving skills, such as CEPAK was advocating for, tended to be sidelined.

The teachers' selective adoption of the technology is to a large extent explained by the belief that the main objective of secondary school teaching is to equip students with the body of factual knowledge required in the examination. Thus, on one hand, use of the computer to produce handouts and test papers was readily accepted because it served the perceived main objective of teaching. On the other hand, for most teachers integration of the technology into lessons was not seen as central in the preparation of students for examinations. In the 1988 survey, teachers were asked to respond to a number of statements on the use of the technology in preparing students for the public examination. The analysis of responses to three of the statements is shown in Table 6.09.

The data in Table 6.09 show clearly that the majority of teachers did not believe that the computer prepared students for the examination better than the two pillars of traditional pedagogy, i.e. the teacher and the textbook. As indicated by the fact that the highest proportions strongly disagreeing with statements A and B were recorded in school U, longer or more varied exposure to the technology did not necessarily create more faith in the computer as opposed to the teacher. In the light of this finding, the tendency (noted in Part 3) for some teachers to abandon

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2. McNeil, L. Talking About Differences, Teaching to Sameness. Journal of Curriculum Studies 19.2, p. 117, 1987.

Table 6.09. Teachers' Responses to Statements on Use of Computers in Preparing Students for Examinations.

A. Learning with computers prepares students for the examinations better than learning with the teacher:

School	n	Percentages of Respondents				
		Strongly Agree 1	2	3	4	Strongly Disagree 5
P	15	7		27	27	40
Q	12	8		42	8	42
R	13	15	7	15	23	39
S	10	10	10	30	10	40
T	7		14	43	43	
U	21	5		10	33	52
Total	78	8	2	22	24	44

B. The computers are better than the teacher for revision for public examinations:

School	n	1	2	3	4	5
P	15	20	13	20	27	20
Q	12		17	25	33	25
R	13	8	15	8	15	54
S	10	10		40	40	10
T	7	14		29	14	43
U	22		9	23	9	59
Total	79	7	10	23	22	38

C. Computer programs prepare students for public examinations better than the textbook:

School	n	1	2	3	4	5
P	15	7	7	20	33	33
Q	12		8	8	50	33
R	12		8	25	17	50
S	9		11	22	44	22
T	7		14	14	43	29
U	22	9	9	32	18	32
Total	77	4	9	22	31	34

students to the machine during computer-assisted lessons must be interpreted as evidence that centrality of the technology in the teaching-learning transaction was still in doubt.

For most teachers, the traditional approaches geared to coverage of the examination-driven curriculum combined with the attitudinal costs and time constraints described in Part 4 to hinder the evolution of pedagogical practices which nurtured learning as a natural process. A teacher who is accustomed to a didactic approach designed to give factual knowledge, will require a lot of convincing to change to a games and problem-solving approach to his discipline. It requires a major change in classroom practice for a teacher, who ordinarily lectures or dictates notes to a passive audience of 40+ students, to be prepared to spend more time in planning computer-assisted lessons in which students are grouped for a variety of activities. A teacher who has been achieving good examination results by giving all the facts, will not readily believe that meaningful learning could result from peer interaction among a group of students around a computer. Neither will the teacher be prepared to risk disruption of a lesson in which he or she is not at centre stage. A teacher who rarely uses a chart or map in a geography or history lesson will not be easily persuaded to give up his time to study, master and use a graphics computer program.

IN-SERVICE EDUCATION OF STAFF IN THE PROJECT

Given the barriers to use of the technology and school system factors which inhibited widespread acceptance of the pedagogical ideas of the innovation, it would appear that different approaches should have been adopted in planning and conducting the in-service education component of the project. An in-depth evaluation of the pilot phase, with a detailed section on the problems encountered in the implementation, should have been carried out by the PD. Such an evaluation, together with those carried out by other evaluators, would have made the planning of Phase II much more realistic, particularly in such areas as the human relations element in the professional management of schools and the influence of the examination-driven curriculum on innovation in the teaching and learning processes. Two external evaluations of the pilot phase (Papagiannis 1985 and Gakuru & Kariuki 1986) hinted that the public examination system was inhibiting the development of the innovative pedagogical practices advocated by CEPAK. However, these findings do not seem to have had much influence in planning the teacher education component of Phase II.

During Phase II evidence was brought to the attention of the PD that in a number of areas, the available research evidence suggested that changes in implementation approaches would lead to better results. For instance, in the baseline study report (Makau 1987) - published six months after the launching of Phase II - the following comments were made:

> Need for more didactic approaches in workshops:
> Given teachers' views on seminars and workshops, that they

expect the experts to demonstrate in practice what has to be done, well-thought on-going evaluation of the implementation strategy is seen as a central aspect of the project. A detailed assessment of the lessons learned...during the pilot (phase) is essential so as to pinpoint areas in which different approaches in Phase II are needed.[3]

Need to take public examinations into account:
The computer innovation should not be seen as a move which distracts schools from their perceived objective of improving performance in exams: the innovation should seek to identify and build on opportunities that enable the teachers and pupils to "cover the syllabus" faster and more effectively.[4]

Role of the SMC
Is the school media co-ordinator at the level of deputy head, head of department or just an advisor? If he is an advisor only, what authority will be responsible for ensuring that his advice is integrated into the academic programme of the school?[5]

The research teams' quarterly reports made several data- based suggestions as to where changes could be made, but by and large the implementation proceeded according to the original planning. Both the size and the strategy of the implementation team remained unchanged.

Size of the Implementation Team

One of the assumptions made in planning Phase II was that one professional educator would have the time to successfully implement the innovation in six schools, a number that rose to eight at the beginning of 1988. As shown in Part 4, the cascade model on which the planning of Phase II was based did not function smoothly. Partly because of time constraints, the PD was unable to give detailed attention to the review of software. It may well have been the case that if on a regular basis a number of programs had been professionally reviewed and their use demonstrated in detail, the dissemination of the ideas of the innovation may have had much more effect on the teaching and learning processes. Perhaps at the beginning of Phase II, a number of teachers who had gained some experience during the pilot phase should, through donor funding, have been seconded to the project to work on a full time basis with the PD. Partly in response to a recommendation by the research team, the idea of having more full time professional implementors was eventually

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3. Makau, B.M. The Pre-innovation Status of the Teaching and Learning Process in Schools. Geneva: AKF (unpublished report), p. 88, 1987.

4. Ibid., p. 89.

5. Ibid., p. 90.

accepted. However, due to delays in recruitment, no additional implementor was taken on until early 1989.

Implementation Strategy

As shown in Part 2, the PD believed that his role in the implementation was to act as a guide and facilitator, as opposed to a didactic teacher trainer. In practice, this philosophy was translated into largely generalised workshops in which teachers were exposed to a variety of ideas on the role of the technology as an educational resource. Teachers were then expected on their own to technically master the computer, sift through the various professional ideas and eventually decide which of them were appropriate for use in lessons. As per discussion in Part 4, this generalised exploration and discovery approach was adopted by most of the teacher tutors who were led workshop sessions. The generalised approach was flawed on four counts. First, the idea that, as opposed to detailed and focused guidance of teachers, generalised guidance is universally the best way of introducing changes in pedagogical practice did not take into account the considerable volume of literacture to the contrary (Rogan & Macdonald 1985, van den Akker 1988). Second, some of the ideas (such as use of LOGO, programming for humanities and language teachers, and interdisciplinary collaboration among teachers of different subjects), did not directly relate to all teachers' immediate professional concerns and were likely to be ignored because they appeared to be irrelevant. Third, exploration and discovery did not take into account that the challenge of mastering a new technology was a daunting one, and for many, the ensuing frustration could lead to dropping out of the innovation. Dropping out of the innovation because of frustration was likely to take place in a school situation where subject departments and SMCs were weak bases for collegial professional interaction. Fourth, encouraging trial and error as the basis of development of new pedagogical approaches did not take into account that teachers in the Kenya school system were used to clear professional guidance from the central curriculum authorities. Teachers were bound to feel that they were being required to spend time and energy on someone else's responsibility.

PART 7

CONCLUSIONS AND POLICY RECOMMENDATIONS

OUTCOMES AND DESIRABILITY OF REPLICATION

Two important findings emerged from the discussion in Parts 3 to 6. First, given the number of computers provided to each of the schools, only a small proportion of students had an opportunity to personally work with the technology. As a result (a) during computer-assisted lessons and out-of-class computer activities, there was intense competition for control of the computers (b) in the mixed schools, female students were unable to successfully compete for control of the computers (c) some teacher users resorted to introducing the technology to a select number of students. A second major finding had to do with the possibility of replication of the innovation on a wider scale. In Part 5, data was discussed to show that the introduction of computers requires financial investments beyond the resources currently available to the majority of Kenya's secondary schools. However, the finding that schools P, Q and U were capable of mobilising local resources for the capital and recurrent expenditures on the technology was an indication that other schools of similar standing could be brought into a more widely based replication of the innovation.

The foregoing findings point to the fact that wider replication of the computer innovation is likely to introduce and/or exacerbate inequality in the learning situation in schools. Only a small proportion of the schools have the financial means to purchase the technology. Further, each of the lucky few schools is unlikely to have the means to acquire the technology such that the computer to user ratios in schools P and U are surpassed significantly. Thus, in-school inequalities in relation to exposure to the technology are likely to continue. At the macro-level of the economy, since in the foreseeable future hardware and some software will need to be imported, the acquisition of computer technology for schools will have to compete with other import needs. Given that Kenya has foreign exchange constraints, import of computer technology will have to be weighed against other needs. Further, it could be argued that importing the technology as an educational resource is undesirable because (1) computer technology has yet to develop to a point where it is at par with traditional educational resources (2) teacher mastery and use of the technology involves time and attitudinal costs which, because they put teaching and learning of the examination-driven curriculum under pressure, are too disruptive of the school system.

One approach Kenya (and other third world countries with similar constraints) could take is to decide that, in order to avoid exacerbating inter- intra-school inequalities, conserve scarce foreign exchange, and avoid disruption of the school system through the introduction of a

technology whose potential is not fully proven, the introduction of computers to more schools should be postponed. Thus, for the foreseeable future available resources for improving the quality of schools should be invested in providing more and better traditional learning materials and improving in- service teacher education. According to this policy approach, computerising schools should only be contemplated when (1) the majority of schools have the financial resources to purchase the technology (2) a local computer industry has been developed, thus obviating the need to use foreign exchange for importation of hardware and software. Postponement would also allow time for the emergence of a clearer picture as to the outcomes of the on-going efforts to computerise schools in developed countries.

The foregoing arguments for delaying the introduction of the technology into schools are counterbalanced by the following factors which favour an immediate venture into computerising more schools. First, while reducing inequity must remain an important goal of a democratic society, refusing to contemplate computerisation because most schools cannot afford the technology will not in itself reduce inequity and, equally important, in the long run it may prove to be counter-productive. Quality differences between schools are likely to continue, whether or not computers are introduced into a few of the institutions. Second, as indicated in Part 1, the Kenya public authorities and sections of the society are aware of the potential of the computer in overall national development. Information technology is already being widely applied in many spheres of the Kenya modern sector of the economy and the applications are likely to increase and diversify. Within national development planning, there is recognition of the link between use of the computer in the work-place and the need for education to help develop the attitudinal, mental and technical skills necessary for appropriate application of the technology. If one of the goals of education is to relevantly prepare youth for participation in development, there is a prima facie case for contemplating the immediate expansion of the computer innovation into schools which can mobilise the necessary funds. To postpone computerisation of schools cannot but result in widening the technological gap between developing and developed countries.

In planning the computerisation of schools it would be helpful to have hard evidence that there is (a) comparative advantage in introducing the technology (b) fair chance that the technology will be accepted and used by the school community. The following six beneficial outcomes of the implementation of CEPAK were clear indications that, on the basis of the foregoing two considerations, it is viable for Kenya to consider computerisation of schools on a wider scale.

1. The implementation of the innovation demonstrated that the technology had a lot potential in the improvement of management, production of teaching and learning materials, and the monitoring of students' academic progress. In these spheres, the technology's potential was shown to be fairly easy to realise because school staff were able to see that performance of existing responsibilities could be greatly improved through automation.

2. The innovation demonstrated that the technology has the potential to make learning interesting and exciting for students. Use of the computer in activities (such as the playing of computer games, creative writing and computer programming out of formal class, and imaginative lessons) which involved the whole personality of the learner seemed to meet the essential conditions for learning as a natural process. Students were observed to be highly motivated by activities which made learning child-centred, i.e. learning which (a) built on the learner's existing knowledge (b) allowed the learner to actively participate (c) allowed the learner a measure of control over the process (d) encouraged interaction with peers as an important source of new knowledge. Nurture of learning as a natural process should be seen as the best way of equipping the learner with life-long skills which enable him or her to fully and relevantly participate in the economy at a future date. The fact that the technology involved in nurturing natural learning is likely to be increasingly used in society is an added advantage in that some of the necessary technical and attitudinal skills are inculcated.

3. Exposure to the innovation resulted in the emergence of new pedagogical perceptions among some teachers. This was true even in the case of some teachers who either did not use the technology or responded to it by identifying some of the limitations of the innovation, e.g inappropriateness of some of the software. The evolution of fresh meditation on the teaching-learning transaction is an important step in the development of pedagogical practices which place the learner at the centre of educational processes.

4. The implementation demonstrated that in the ordinary Kenya secondary school, the introduction of computers was likely to be of interest to some members of the school staff. In all six schools a few members of staff were excited by the technology and made efforts to master and use it in their work. The emergence of this core of staff was influenced by previous exposure to computers, previous involvement in educational innovations, and the identification of personal goals for learning to use the technology. In relation to the future, the early adoptors provided a knowledge base on which the further development of the objectives of the innovation could build.

5. Some teachers, particularly in school U, made an effort to integrate the technology in the teaching and learning of various disciplines in the school curriculum. A few of the teachers were able to use simulation imaginatively and the concept of play as effective learning strategies. Thus, these teachers demonstrated that the computer could be used to make learning the natural process that it should be.

6. The innovation succeeded in generating interest in other educational technologies. A few teachers, particularly in school U, began to use the overhead projector and video in their teaching. This was evidence that there was new hope for the wider use of teaching aids, an area which in the baseline study had been observed to be woefully lacking.

Overall, the innovation proved that the excitement associated with mastery and use of the new technology is a sound base for a wider discussion and reform of curriculum processes. However, the beneficial outcomes of the innovation were counterbalanced by a number of inhibiting factors, which should be taken into account in the future.

The introduction of computers into more Kenyan secondary schools should take into account the following five factors which were observed to have inhibited the implementation of CEPAK.

1. **Size of the Threshold Package of Equipment**

In relation to student enrolments, the number of computers was small. In terms of operating the keyboard, the great majority of the students received very limited personal exposure to the technology. With regard to the future, it should be borne in mind that since the technology is expensive, it might not be wise to seek solutions based on providing more hardware. A more realistic solution may lie in a school devising approaches which, while reducing inequity and seeking to make learners active, take into account that more computers cannot be afforded.

2. **Lack of Fit Between the Technology and the Curriculum**

Lack of fit between the technology and the Kenya secondary curriculum inhibited the implementation in three ways. First, because most of the software was imported, the element of cultural bias greatly curtailed the number of CAL programs which could be acquired in languages and the humanities. The preponderance of imported science and mathematics software (dictated by the universality of content in these disciplines), confirmed belief that the technology was less relevant to learning in the humanities and languages. Second, traditional print media on which the curriculum is largely dependent is different from the new technology. For instance, it is necessary to master a considerable array of technical operations in order to be able to extract knowledge from computer programs; by contrast, in order to acquire knowledge from books, all one needs is to be able to read intelligently. Third, some of the good programs cover some aspects of syllabus topics in much more detail than expected by the curriculum planners. Thus, a teacher opting to use one these programs without prior review and selection of what sections he would introduce to his class, would spend much more time in covering a topic than is allocated in the official syllabus. Because of the extra time demand for prior review of programs and/or hazy knowledge of criteria for reviewing, and inadequate mastery of technical operations, some teachers either opted not to use the computer in lessons, or encouraged students to run the programs with minimal involvement of the teacher.

3. **Time and Attitudinal Constraints**

An important conclusion of the study into CEPAK is the finding that mastery of technical operations of the computer and the development of functional uses of the technology requires the expenditure of more time

and emotional energy than imagined by an expert user. Computers have been proliferating in homes and schools in Western society for more than a decade. For those in the industry, addicted home users and those with long exposure to the technology, computers are exciting, tantalising and manifestly simple to operate. There is a wealth of alluring software available to enable the user to do things previously not possible. With regard to education there are many claimed uses for the technology and the possibility of changing the whole nature of the teaching-learning process. The information revolution promises greater and greater access to data which "will change our lives." As far as the computer expert is concerned, all this should be obvious to the novice computer user.

However, for the beginner it is not all so simple. Using a computer even for the most basic menu-driven program assumes a familiarity with the keyboard. Few of the teachers in the project had ever operated a typewriter. Consequently, finding desired characters on the computer keyboard was a major problem. As opposed to reliance on the typewriter, the versatility of the wordprocessor offers major advantages in the production of documents. But, however much the wordprocessor may appeal to the professional writer, a teacher who finds it takes 30 minutes to type and print a page of notes, which he previously manually wrote in 15 minutes, will not find the same appeal. The spreadsheet, with its ability to manipulate numerical data, has little appeal for the teacher who finds the electronic calculator much faster and simpler to operate. The simplest CAL program demands the expenditure of time in mastering the basic commands and in enabling the user to get to a point where the program can be used quickly and efficiently. Most programs demand repeated reference to the manuals before expertise is acquired. Some manuals assume familiarity with the computer which the beginner does not have. Some programs have small but irritating bugs and in some cases information or instructions appearing on the screen is too technical for the novice.

The computerphobia and extra demands on time associated with the foregoing influenced some school staff either not to take an interest in the innovation or to drop out after the initial orientation.

5. **The School System**

The hierarchical and authoritarian school system inhibited the innovation in four ways as follows:

(a) The schools' senior management staff were ambivalent in their response to the innovation because they perceived it to be somewhat out of step with the centrally mandated curriculum. This perception to a large extent explains the schools' reluctance to make binding policy on the integration of the technology into the curriculum.

(b) Departure of some of the early adoptors of the technology (associated with decisions of higher authority and perceptions that teachers were poorly remunerated) weakened the core of staff on whom dissemination of the ideas of the innovation depended.

(c) Perceptions that teaching had a low status and was poorly remunerated prevented the development effective channels through which collegial interaction over professional issues could take place among teachers. In particular, most staff perceived the subject department system as part of the administrative hierarchy of the school, rather than a focal point for the professional development teachers in a department. Thus, the subject department system did not play the expected role in the attempt to integrate the technology into the curriculum. As in the case of the head of department, the new role of school media co-ordinator was perceived as largely administrative in relation to the innovation. This perception of the SMC and the fact that those appointed to the position did not have their previous teaching loads reduced, weakened the SMC's professional role in disseminating the innovation.

(d) The examination-driven curriculum was interpreted by teachers and students as requiring mastery of factual knowledge originating from the teacher and the textbook. The innovation's emphases on (1) the need for the learner to play a much more active role in his or her learning (2) activities which encourage mental skills (such as problem- solving) seemed to be a departure from what was perceived as the best way of preparing students for the public examination. In developing countries such as Kenya and indeed in school systems in the West which are moving towards teacher accountability in the delivery of observable results from formal schooling, society sees formal education as mainly for providing graduands at a given level with the means of securing further education and employment opportunities. The success of the school system is judged in terms of good examination results. Such results can be achieved within the framework of traditional pedagogy where students are equipped with the requisite volume of factual knowledge. The perception that teachers could get by through continued reliance on traditional pedagogy combined with the natural human dislike of change to hinder the development of the innovative practices advocated by CEPAK. The teacher, in common with most other human beings, does not readily embrace change. The familiar, tried and trusted modus operandi is comforting. One knows where one is. Change is threatening, especially where change involves expenditure of more time and effort in mastering unfamiliar approaches based on a new technology.

5. **The Implementation Strategy**

Two major findings emerged in relation to the implementation strategy. First, given the number of schools in Phase II, computerphobia among teachers, technical and professional problems in employing the technology as an educational resource, and a system which at the school level was not accustomed to taking the lead in innovative curricular changes, one professional could not adequately meet the challenge of implementing the innovation. Second, the generalised exposure to various uses of the technology planned to be followed by detailed exploration and discovery by the teacher, fell short of the desirability of sequencing and focusing training activities in relation to the development of the desired pedagogical approaches. On the contrary, on the part of the ordinary teacher, tinkering with the technology on the basis of trial and error

resulted in frustration which in some cases contributed to dropping out of the innovation.

RECOMMENDATIONS

Integrating Technology into Curriculum Processes

The findings of the Phase II study show that if Kenya is to undertake the introduction of computers into more schools, there will be need for careful planning. It is suggested that such planning should be based on the following four general precepts:

1. Through the Ministry of Education (ME), the Government of Kenya (GOK) should take full responsibility for policy and planning in relation to the computerisation of schools. In particular, the institutions which (at the national level) plan, guide and supervise school curricula should be fully involved. These institutions are the Kenya Institute of Education (KIE), the school inspectorate and the Kenya National Examinations Council. ME's responsibility should take two forms. First, through discussion in appropriate committees, the role of computers as an educational resource should be integrated into curriculum development, the public examination system, and school management. Second, as part of the personnel establishment of KIE, a unit should be set up to (1) steer the integration of computers into the school curriculum (2) undertake the training of school staff in mastering and applying the technology (3) develop local capability in the production of educational software which is suitable for the Kenya curriculum (4) take charge of the preventive maintenance and repair of computer equipment in the schools.

2. In order to build local expertise on the role of computers in education, GOK should seek the involvement of knowledgeable consultants. It is preferable that such consultants should have knowledge and experience of the education system in Kenya or a comparable third world country.

3. In introducing and developing the use of computers in schools, a research and development (R&D) strategy should be adopted. Approaches written into original planning should be treated as working hypotheses which are subject to modification during the actual implementation. An important aspect of the R&D strategy should be the documentation of all the steps in the process, including inputs (e.g. planning, equipment and materials, training activities, use of time), outcomes and suggestions to guide further planning.

4. The issue of costs should be kept in perspective. For instance, schools wishing to acquire computers must be able to mobilise parents and communities to raise the necessary financial resources. Once schools have acquired the technology, they should be encouraged to actively explore ways in which the technology could be used to raise funds for recurrent and replacement or expansion capital costs.

Devising a Workable Implementation Strategy

An important aspect of introducing computers into schools is to devise a workable implementation strategy. The first step should be to introduce those aspects of the technology which can immediately be seen to be productive and which can be implemented with the least disruption of normal school practice. The first question that should be asked is, what can computers realistically do to improve the quality of education in the schools?

Computer Managed Education

As shown in the implementation of CEPAK, computer managed education (CME) is a sphere which is likely to be readily accepted by the school community. Planning should take into account four aspects of CME as follows:

(a) Financial Management

If school finances are to be computerised, then the accounts staff must be trained in the operation and possibilities of the spreadsheet and other commercial accounting software. Such training should take into account what the schools want to produce in way of accounts documents. Since student and teacher databases are an essential part of financial management, it is necessary for the accounts staff to be familiar with a database program and have the knowledge of how to transfer data from the database to a spreadsheet and vice versa.

(b) General School Administration

The administration of the school involves the production of many repetitive documents such as joining instructions, school rules, class and house lists, staff lists, circulars and notices. Once produced, these documents usually require minimal adjustment from year to year and are tailor-made for the computer. All school secretarial staff should be quickly made expert in the use of the wordprocessor and the database.

(c) Production of Teaching and Learning Materials

Traditionally school examination papers are presented in hand-written drafts by teachers to school secretaries who prepare typed stencils. This process would be greatly speeded up if secretaries mastered the wordprocessor. As observed in Phase II, teachers who mastered the wordprocessor greatly appreciated the freedom from dependence on school secretarial staff. Such teachers were able to accurately produce desired teaching and learning materials. Thus, teachers should be encouraged to master the wordprocessor. Teachers should be trained in the use of the wordprocessor to the extent of being able to enter data, edit and format their work, print copies and cut stencils. If good easily operated test-generating software is available, a start should also be made on developing and maintaining test item banks on a departmental basis.

(d) Management of Academic Data

The traditional practice in schools is for a teacher to mark test scripts, record the scores on a subject marksheet and later transfer the data to a master marksheet covering all subjects. Continuous assessment scores are aggregated with examination marks, the total score and class position is calculated for each student and then the data in the master marksheet is copied onto individual report forms. This is a laborious and time-consuming process which causes a lot of panic and confusion at the end of term. The computer can be utilised to reduce this clerical drudgery. All that is required is for teachers to be trained to enter the marks into a spreadsheet template from which individual reports can are printed.

So as to be able to make decisions on teaching-learning, e.g. in relation to teacher development and remedial work for weak students, a school's senior management needs comparative data on performance in various subjects and streams. A small cadre of teachers in the school need education in the basics of analysis of measurement data and training in simple procedures for the production of relevant statistical measures.

Exposing Students to the Technology

Given that, relative to student enrolment, only a small number of computers are likely to be acquired, it is important for planning to explore ways in which the technology could be used by students outside formal lesson time. As shown in Phase II, use of the technology in out-of-class activities is a profitable opening. As soon as possible, computer clubs with representation from all classes should be formed. Schools should explore ways of providing access to the computers for as many students as possible. Other clubs should be introduced to software which has a bearing on their activities. A program such as **Branching Story** would be of interest to the creative writing club. Database programs could be functionally introduced to clubs such as the geographical and wildlife societies. In some of the specialist subject clubs, such as the mathematics and science clubs, CAL programs could be used to provide imaginative and unusual insights into specific concepts. Some clubs could teach the basics of computer programming to interested students. All clubs could co-operate in producing a regular newsletter and the school magazine.

Using the Technology as a Catalyst in Teacher Development

Integrating computers into the normal curriculum should be recognised as one of the most challenging aspects of computerising schools. The approach should be to carefully guide teachers from the "known" to the "unknown." Initially the implementation should help teachers to use the capabilities of the computers to improve their current pedagogical approaches. Simple drill and practice software would easily fit into the examination-dominated classroom. Language teachers who have learned how to use the wordprocessor may be persuaded to explore its possibilities in the sphere of creative writing, which is already part of essay

writing. Suitable graphics programs could be introduced to subject teachers who are already involved in drawing maps and/or graphs.

The second step in training for the integration of the computer into the curriculum is to help teachers to begin to analyse their current approaches and to use the computer to develop alternative approaches. The third step in the innovatory process is for teachers to arrive at a point where pedagogical approaches developed through use of the computer translate into lessons where the computer is not in use.

Good and imaginative CAL programs could be used to begin the debate on the worth and effectiveness of current teaching styles. If teachers could be persuaded to use software which enables them to do things they were previously unable to do in the normal classroom, new pedagogical insights could be imparted. However, this indirect approach needs to be backed up by more focused teacher education activities.

It is essential that any effort to use the computer as a catalyst to promote new pedagogical perceptions should have a fresh look at what learning is all about and how effective learning occurs. Since teachers have become so attached to their current teaching styles, are so convinced of what constitutes learning in their disciplines and so sure of the effectiveness of their pedagogy in promoting that learning, it will probably be necessary to approach a discussion of the learning process by exposing teachers to a learning experience in a subject in which none of them has any previous experience. One might choose **Turtle Geometry** in LOGO, or the writing of a simple recursive procedure in PILOT, or a computer game in which commands and problem-solving strategies have to be developed and applied. The exercise should be used to get teachers to analyse what they had to learn, how they learned it and how that learning might have been improved upon. The discussion could be guided by the following questions:

(a) What previous knowledge was required?
(b) What background knowledge, factual or otherwise, had to be provided?
(c) What basic content had to be learned and memorised and why?
(d) What skills had to be developed?
(e) How were these skills developed?
(f) How much consolidation or practice was needed?
(g) What opportunities were provided for extension of the basic skills acquired? How was this extension achieved and what additional content had to be learned and retained in order to make this extension possible?
(h) What were the difficult areas and why were they difficult?
(i) What key points should be remembered at the end of the learning session?
(j) Where would a future learning session go?

The next line of attack might be to take a topic from a subject syllabus and get a subject teacher to detail how the topic is traditionally presented in a 40-minute lesson. This should be followed by an analysis of the merits and demerits of the traditional teaching approach. This

discussion should be critical and hard hitting, with teachers being required to justify their current teaching styles. Based on providing answers to the 10 questions given above, teachers could then be asked to suggest an alternative approach to the teaching of the topic. A good CAL program covering the same topic could be viewed by teachers and its strengths and weaknesses in relation to its usability in a lesson discussed.

Discussion could follow on approaches used in teaching and learning various topics in different subjects. It might be desirable to isolate various kinds of learning required by different disciplines, e.g. in relation to facts, specific skills, manipulation of data, problem-solving techniques, and layout of work. This could be followed by a discussion of how these kinds of learning could best be promoted given the constraints of the classroom and the time available. Are there any areas where use of the computers could help? Is there a CAL program available which would do things better than the teacher? What strategies are appropriate to the evaluation of each kind of learning?

To enable teachers to break away from their traditional approaches, there should be a critical analysis of the role of the commonly used teaching strategies, such as lecturing, note-giving, question and answer, class discussion, use of the chalkboard, consolidation activities, homework and correction of work, use of teaching aids, diagnosis of students' difficulties, remedial activities, testing, grouping of students, peer learning. Discussion should attempt to answer the question, can the computer be used to make any of these tasks irrelevant or more easily managed?

Further discussion and demonstration sessions might explore the role of the computers in the following areas: preparation of schemes of work, lesson preparation, build-up of teaching notes and other resource material, preparation of student handouts, preparation of examination papers, development of test item banks, juxtaposition of the computer with other educational technologies.

The activities suggested above should become an integral part of school subject department meetings. Subject departments should be encouraged to meet on a regular basis to discuss specific uses of the technology.

School Media Co-ordinators

The idea that specially trained SMCs should be in charge of in-school professional guidance of other teachers should be abandoned. SMCs who are teachers could be appointed and trained to undertake special responsibilities of non-professional nature, e.g. the day to day preventive maintenance of the equipment, or looking after the software library. Alternatively, if funds allow, it might be a better idea to appoint and train a non-teaching member of staff to be in charge the non-professional tasks which in Phase II were observed to be part of the SMC's responsibilities. Appointing non-teaching staff to be in charge of the equipment would have two advantages. First, teachers would have more

time to devote to the professional development of the use of the technology. Second, inherent competition between teacher-SMCs and heads of subject departments would be forestalled.

Some Training Guidelines

The following general training guidelines, all based on the Phase II experience, should be taken into account in computerising schools:

(a) The introduction of teachers to the computer and the use of software should be done in as didactic a manner as possible, with the emphasis being on enabling teachers to gain functionality and confidence with the minimum amount of stress and in the shortest time possible.

(b) The implementors should have an appreciation of the initial difficulties of beginners. Simple step by step handouts should be available to minimise these difficulties. Observed operational snags should be clearly explained.

(c) The training should be sequenced from basic skills, through intermediate skills to advanced skills. Learning opportunities for trainees at various levels of skill should be provided. On-going evaluation of trainees' needs and problems is essential. Remedial training, based on this evaluation should be provided.

(d) The central implementation office should develop criteria for the review of educational software. Further, by way of example to the schools, the central office should review a number of programs. However, school staff should be fully involved in review of programs so that all available software is covered and written notes for the guidance of teachers produced.

Suggested Objectives for an Expanded Project

To conclude this report, it is suggested that a government sponsored project to extend computerisation into more secondary schools should be guided by the following objectives:

1. To use the computers as a tool to improve the financial and general management of the school by training the relevant non-teaching and teaching staff in the use of appropriate software.

2. To train teaching staff in the basics of entering data for the efficient management and analysis of students' academic data.

3. To train teaching staff in the basics of wordprocessing so that production of teaching and learning materials is undertaken more efficiently.

4. To expose students to the possibilities of the technology through the medium of computer clubs, other clubs and any other suitable out-of-class activities.

5. To provide schools with a sample of good CAL programs and other resources which would provide additional reference material and a source of new ideas.

6. To identify CAL software which is appropriate for the Kenyan curriculum, and which improves the quality of teaching-learning by making syllabus coverage more efficient.

7. To develop local software and other learning materials.

8. To use good and imaginative CAL software to begin the process of analysing and improving current approaches to teaching and learning.

9. To guide teachers to adopt learner-centred pedagogical strategies through in-class use of the computer and other technologies.

10. To identify and train a few teachers who could guide colleagues in mastering use of the computer as an educational resource.

11. To explore ways in which school computers could be used to generate funds for recurrent and further capital costs of computerisation.

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